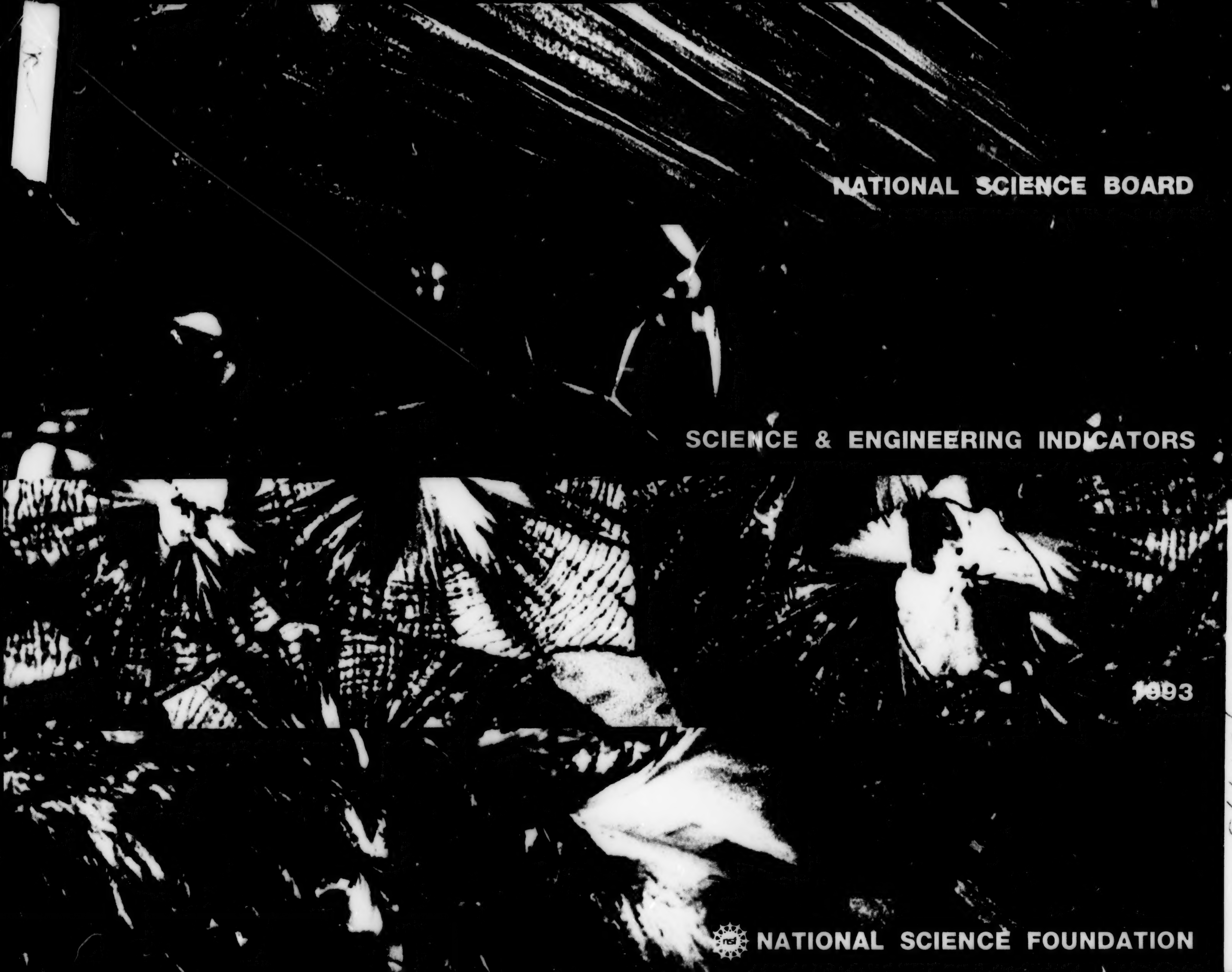

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SCIENCE & ENGINEERING INDICATORS

1993

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SCIENCE & ENGINEERING INDICATORS

1993

NATIONAL SCIENCE BOARD

I

The Cover

The photomicrographs on the cover depict crystallites of the common vitamins (from left to right) *Cholecalciferol (Vitamin D_3), Biotin (Vitamin H), Niocin (a B-complex vitamin)*, and *Ascorbic Acid (Vitamin C)*. These images convey the beauty and excitement of science and demonstrate the synergy of the arts and science.

Vital Amines. The term **vitamin** derives from experiments conducted early in this century which indicated that proper nutrition was dependent upon the introduction of one or several **vital** nitrogen-containing **amines** into the diet. Vitamins are organic molecules (not necessarily amines) that are essential to metabolism in all living organisms. While these molecules serve essentially the same role in all forms of life, higher organisms have lost the ability to sythesize vitamins.

The Image

Photomicrography. The images on the cover were prepared using the technique of photomicrography by Michael W. Davidson, a research scientist in charge of the optical and scanning probe microscopy facilities at the National High Magnetic Field Laboratory (NHFML) at Florida State University in Tallahassee. Davidson has won over 30 awards in scientific and industrial photography competitions. His research interests include liquid crystalline biological systems, the packaging of DNA in virus heads, and the interaction of drug molecules with DNA.

The National High Magnetic Field Laboratory represents a model partnership for the future. This federal-state-industry cooperarative enterprise holds the potential for broadening opportunities for research and education. NHMFL is operated by a consortium which includes Florida State Univerity, the University of Florida, and Los Alamos National Laboratory. It is funded primarily by the State of Florida and the National Science Foundation.

Recent developments in the material sciences have led to an enhanced interest in the expanding field of photomicrography. For example, the technique has become indispensable to the semiconductor industry for characterizing manufacturing defects and monitoring the successive stages of integrated circuit fabrication.

Photomicrography captures the images seen in the microscope onto photographic film to obtain "hard copy" for research records. In a classroom environment, classical photography assignments can be coupled with science microscopy studies to provide a multidicsiplinary program in photomicrography.

To "read more about it" and learn about ways to introduce photomicrography at the high school level, see Michael W. Davidson, "An Introduction to Photomicrography," *Photomicrography*, September 1991; "Some Artistic Techniques in Photography," *Journal of Biological Photography*, October 1991; and "Moon Rocks Under the Microscope," *Microscopy and Analysis*, July 1993.

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Letter of Transmittal

NATIONAL SCIENCE BOARD
4201 Wilson Boulevard
ARLINGTON, VIRGINIA 22230

December 8, 1993

My Dear Mr. President:

It is my honor to transmit to you, and through you to the Congress, the eleventh in the series of biennial Science Indicators reports—*Science and Engineering Indicators—1993*. The National Science Board is submitting this report in accordance with Sec. 4 (j) (1) of the National Science Foundation Act of 1950, as amended.

The *Science and Engineering Indicators* report provides policymakers in both the public and private sectors with a broad base of quantitative information about U.S. science and engineering research and education and U.S. technology in a global context. The data and analysis in this report are especially relevant to our Nation during these first years of the Post-Cold War era.

Science and technology, including basic research, are key factors in meeting our strategic goals of improved international competitiveness and enhanced health and economic and social well-being. The *Science and Engineering Indicators* report series contributes to a better understanding of the science and technology enterprise and will be helpful as together we define and assess priorities and accomplishments.

Mr. President, the National Science Board is proud to note that the *Science and Engineering Indicators* report is internationally renowned and has become a model for other countries. I join my colleagues on the National Science Board in expressing the hope that you, your Administration and the Congress will find this report useful as you set priorities, make decisions on investments and seek solutions to our national problems.

Respectfully yours,

James J. Duderstadt
Chairman

The Honorable
The President of the United States
The White House
Washington, DC 20500

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Introduction

An Historical Perspective

It has been more than 20 years since the National Science Board (NSB) issued the first edition of what has since become the biennial *Science & Engineering Indicators* report. Consistent with its congressional mandate to be concerned with the state of science and engineering in the United States, the Board made an early, explicit decision to work with other federal agencies to develop output indicators and input indicators to help describe major scientific advances and technological achievements, as well as gauge the contribution of science and technology both to specific national goals and the broad national welfare.

In preparing the 1993 report, the NSB Subcommittee on Science and Engineering Indicators reviewed the history and original goals of the NSB in developing an Indicators effort. On May 19, 1976, Roger Heyns, Chairman of the NSB's Science Indicators Committee, was invited to testify at hearings before the House of Representatives' Subcommittee on Domestic and International Scientific Planning. At this hearing, Heyns outlined some of the main purposes and functions of the reports:

- to detect and monitor significant developments and trends in the scientific enterprise, including international comparisons;
- to evaluate their implications for the present and future health of science;
- to provide the continuing and comprehensive appraisal of U.S. science;
- to establish a new mechanism for guiding the Nation's science policy;
- to encourage quantification of the common dimensions of science policy, leading to improvements in research and development policy-setting within federal agencies and other organizations; and
- to stimulate social scientists' interest in the methodology of science indicators as well as their interest in this important area of public policy.

Over the years, the *Science & Engineering Indicators* reports have evolved, expanding their coverage, and refining and improving the methodologies, presentations, and analyses of the indicators. The NSB Subcommittee reviewed the original objectives established 20 years ago; it noted that they have been met and are still valid. Indeed, the first objective (international comparisons) is perhaps even more important today than it was in 1972. In recognition of this, one of the major enhancements, of the *Science & Engineering Indicators—1993* report is an expanded coverage of international comparisons.

Audiences

In developing the *Science & Engineering Indicators* reports, the Board is aware of their value and use as reference documents as well as policy documents. The reports now serve the needs of a very wide audience including decisionmakers from government (in particular the congressional and executive branches), the industrial and academic sectors, nonprofit organizations, and professional societies. One of the continuing objectives of the Board is to be relevant to this broad audience in the United States, as well as abroad, who have come to rely on comprehensive and objective indicators to assist them in their responsibilities.

The NSB Subcommittee, before preparing this report, contacted a variety of users to determine policymakers' needs and views about *Science & Engineering Indicators*. Their response was overwhelmingly positive. Several important topics were suggested, and many of these ideas were incorporated in *Science & Engineering Indicators—1993*.

Coverage of Indicators

The coverage of several important topics or themes have remained constant over the years, regardless of chapter configuration. As stated earlier, international comparisons were an initial goal of the report and have been greatly enhanced in the 1993 report. The National Science Board and the National Science Foundation, in cooperation with the Organisation for Economic Co-operation and Development (OECD), have taken a leadership role in developing science indicators-type reports and quantitative information on science and technology as a basis for policymaking and as a tool for research and assessment on a worldwide basis.

The success of providing valid and comparable data depends on the active participation and cooperation of nations who now are engaged in developing their own national science and engineering indicators. Among the OECD member countries, Australia, Canada, France, Germany, Italy, Japan, the Netherlands, and the United Kingdom, to name a few, are engaged in national indicators activities. The Commission of the European Communities is establishing its own science and engineering indicators program. Over the past year, National Science Foundation staff have worked with a number of other countries such as Brazil, India, Indonesia, and Mexico as they also have begun or expanded their own science and engineering indicators efforts. Additionally, the National Science Foundation is working in partnership with the OECD to assist "economies in transition," such as Russia and Central European countries, to establish comparable science and technology indicator systems. The National Science Foundation continues its cooperation in science indicators activities with the Pacific Economic Cooperation Council (PECC) and Asian countries.

The quantification of the outputs and impacts of science and technology was an original goal. *Science Indicators 1972* contained some measures of scientific publications and citations by fields and countries. The National Science Foundation took an early lead in developing the field of bibiliometrics; these indicators have been greatly refined and expanded and improved over the years. Once thought new and experimental, they are now accepted the world over as important output indicators. A variety of patent indicators have been used and improved as another measure of inventiveness and output from R&D, particularly with regard to the industrial sector. These indicators are now being considered as important metrics in broad performance assessments.

Assessments of what was called "Public Opinion of Science" in the 1972 report have been a another continuing feature of the *Science & Engineering Indicator* series. Evaluating, quantitatively, the complex, but all-important public attitudes toward and understanding of science and technology in a manner that accurately portrays those attitudes and changes over time has led to the development and evaluation of ever more comprehensive and refined public attitude survey instruments. The National Science Foundation has worked with the Commission of the European Communities, Japan, and a number of other countries to increase the comparability and coverage of survey questions, including questions on environmental topics and issues. The National Institutes of Health joined the National Science Foundation in this endeavor, supporting the development of a whole set of new indicators related to the measurement of public understanding of biomedical and behavioral science concepts and scientific reasoning. This report encompasses expanded coverage of public attitudes and understanding in terms of international comparisons and increased subject matter.

Among the more visible and significant trends to which *Science & Engineering Indicators* must respond is the globalization of science and technology. The importance of international comparisons and international collaboration in developing indicators data has already been stressed. This report includes data on trends in international collaboration. In view of the importance of regional cooperation, the report also presents regional data for Europe, Asia, and North America, for example.

In the field of education indicators,[1] this report includes information on global human resource development in science and engineering. Special attention also has been paid to education and employment in science and engineering of women and minorities.

An effort was made in the *Science & Engineering Indicators—1993* report to provide information on a number of topics or developments thought to be of interest to policymakers such as the changes in defense R&D and the effects of defense conversion on R&D expenditures and science and engineering employment patterns. Additionally, new information is provided on international and domestic cooperation and partnerships in science and engineering. Some information is also presented on the immigration of scientists and engineers from Russia. A discussion is included on the future national competitiveness in high-technology industries for eight Asian countries.

Universities have increased their role in the performance of the Nation's R&D. However, concern is currently being expressed about changes and pressures on U.S. research universities. Because of its importance, a separate chapter is devoted to academic research.

U.S. science and engineering, and the technologies that emerge from related research and development and innovation in the private and public sectors, are widely recognized for their contributions to the Nation's economic growth. Therefore, a chapter on technology development and competitiveness is included.

From the outset, the vision of the National Science Board has been to provide a continuing and comprehensive appraisal of U.S. science and engineering. The *Science & Engineering Indicators—1993* report continues this excellent tradition.

---

[1] This report contains chapters on precollege science and mathematics education and higher education in science and engineering. For further information on these topics, see Division of Research, Evaluation and Dissemination. 1993. *Indicators of Science and Mathematics Education 1992.* NSF 93-95. Washington DC: National Science Foundation.

Acknowledgments

The National Science Board extends its appreciation to the staff of the National Science Foundation for preparing the report.

Organizational responsibility for the volume was assigned to the Directorate for Social, Behavioral and Economic Sciences, Cora B. Marrett, Assistant Director.

Primary responsibility for the production of the volume was assigned to the Indicators Program, under the direction of Jennifer Sue Bond of the Division of Science Resources Studies (SRS), Kenneth M. Brown, Director. The Office of Planning Assessment (OPA) and the Directorate for Education and Human Resources (EHR) also contributed to portions of the report.

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Overall editing of the report was performed by Nita Congress, consultant. Eileen Kessler, John Bockelman and the staff of Studio Services provided composition services. Patricia Hughes and Pat Bryant of the NSF Publication Services Section were responsible for the desktop publishing and printing process.

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Overview

Science and Technology: Changes and Challenges

XV

SCIENCE AND TECHNOLOGY: CHANGES AND CHALLENGES

◆

"This country must sustain world leadership in science, mathematics, and engineering if we are to meet the challenges of today . . . and of tomorrow."

PRESIDENT WILLIAM J. CLINTON
November 23, 1993

◆

The U.S. science and technology (S&T) enterprise is key to our future. It is vital to our Nation's economic growth and productivity and makes invaluable contributions to our personal health and well-being. Against the backdrop of new political realities—the end of the Cold War, the collapse of the former Soviet Union, and the resultant and concomitant changes in defense requirements—national investment in research and development (R&D) and education and training is particularly significant.

Further, the increased globalization of national economies underscores the need to analyze and understand current trends in both cooperation and competition in science and technology. Many nations have increased their scientific and technological capabilities, resulting in growing economic competition from abroad in technological products and services. Growing S&T investments in newly industrialized economies and the development of new regional blocks such as Europe, North America, and the Pacific Rim call for increased attention by policymakers to enhanced opportunities for—and challenges to—scientific and economic interaction.

This report describes U.S. science, engineering, and technology trends in a global context, and provides insights on how investments and priorities are changing over time. S&T human resources, in all their diversity, are essential to our economy and national security. Therefore, information on the science and engineering (S&E) pipeline—precollege education, higher education, and the S&E workforce—is presented. In a democracy such as our own, public attitudes and public understanding are of major importance and have an impact on decisions in both the private and public sectors. Therefore, the report presents information on science and technology in a societal context.

This overview section highlights some of the cross-cutting themes and findings detailed in the remainder of this report.

U.S. scientific and technical capabilities should be viewed in a global context.

- The United States still leads all other countries in the amount of total R&D investments, but other countries have increased their R&D capabilities and are either closing the gap with or leading the United States for some indicators.
- Total U.S. expenditures on R&D reached an estimated $161 billion in 1993, or 2.6 percent of the gross domestic product (GDP). In 1991, the R&D/GDP ratio in Germany was also 2.6 percent (2.8 for the former West Germany alone), and the ratio for Japan was 3.0 percent.

- Continued slow growth is expected for the Nation's R&D investment; since the late 1980s, there has been a worldwide slowing in R&D funding growth.
- The United States spent 11 percent more on R&D than Japan, the former West Germany, and France combined in 1991, but these three countries spent 17 percent more on nondefense R&D than did the United States. Only in Japan, however, has nondefense R&D grown faster than in the United States since the early 1980s.
- The nondefense R&D/GDP ratio in the United States is less than or equal to many other industrialized countries. In 1991, the U.S. ratio was only 1.9 percent, which is equal to that of France, but less than the 3.0 percent ratio in Japan or the 2.7 percent in the former West Germany.
- The United States continues to lead the industrialized world in the performance of industrial R&D, but over the past two decades, the U.S. share of industrial R&D performed by the Organisation for Economic Co-operation and Development countries has fallen. Despite this decline, the United States remains the leading performer of industrial R&D by a wide margin, even surpassing the combined R&D of the 12-nation European Community.
- Twice as many scientists and engineers are engaged in R&D in the United States as in Japan; however the United States and Japan now have similar proportions of such researchers in their respective workforces.
- The United States has high participation rates in university education. However, Canada and some Central European and Asian countries have higher participation rates in natural science and engineering (NS&E) degrees by their college-age populations than does the United States.
- In 1990, six Asian countries produced more than one-half million NS&E bachelors degrees, slightly more than the number of NS&E degrees produced in Europe and North America combined.
- The U.S. share of the world's influential scientific publications far exceeds that of any other country. Scientists and engineers in the United States, the European Community, and Japan produce about two-thirds of the world's premier scientific literature.

⁂

"It is essential to recognize that technical advances depend on basic research in science, mathematics, and engineering. Scientific advances are the wellspring of the technical innovations whose benefits are seen in economic growth, improved health care and many other areas. The Federal Government has invested heavily in basic research since the Second World War and this support has paid enormous dividends. Our research universities are the best in the world; our national laboratories and the research facilities they house attract scientists and engineers from around the globe."

PRESIDENT WILLIAM J. CLINTON AND
VICE PRESIDENT ALBERT GORE, JR.
Technology for America's
Economic Growth,
New Directions to Build
Economic Strength
February 22, 1993

⁂

The S&T enterprise is increasingly global in nature, and international interaction is increasing.

- The internationalization of industrial R&D is intensifying. From 1980 to 1991, U.S. firms generally increased their funding of R&D performed abroad. Since 1985, U.S. firms' overseas R&D financing has increased nine times faster than that performed domestically. Offshore R&D funded by U.S. industrial firms now equals 11.3 percent of their own domestic R&D expenditures. Foreign R&D comprised more than 10 percent of industry's total in the United States, Canada, the United Kingdom, and France in 1990. The number of multi-firm international R&D alliances grew from about 250 in the 1970s to almost 1,500 in the 1980s.

- International coauthorship of scientific articles represents another indication of enhanced collaboration. In 1991, 11 percent of the world's articles were internationally coauthored—this is twice the percentage from a decade earlier. This increase in international cooperation is evident in several fields, but especially in physics, mathematics, and earth and space sciences. Although U.S. researchers still collaborate most frequently with colleagues in the United Kingdom and Germany, there has been increased cooperation with France, Japan, and Italy.

- The excellence of the U.S. higher education system attracts growing numbers of foreign students. These students continued to increase as a proportion of U.S. doctoral degrees in 1991, particularly in engineering and mathematics; foreign students received over 25 percent of all natural science degrees, over 40 percent of math/computer sciences degrees, and over 45 percent of engineering degrees awarded that year.

- Among foreign citizens, students from Asian countries receive three times more S&E doctorates from American universities as do students from all European countries and the Americas combined. More than three times as many Asian S&E doctoral recipients plan to stay and work in the United States as foreign S&E doctorates from the Americas and Europe.

The U.S. is undergoing a change in the structure of its R&D investments.

- The Federal Government provides a decreasing fraction of national R&D support—an estimated 42 percent in 1993, down from 46 percent in the mid-1980s. Industry provides more than half of all funds (52 percent); and the combined share of state government, university, and nonprofit support has doubled from 3 to 6 percent since 1985.

- Universities conduct an increasing share of the R&D performed in the United States, growing from 9 percent in 1985 to 13 percent in 1993. Industrial firms are still responsible for performing most of the Nation's R&D—68 percent—but their share of the total national effort fell over this same period.
- Individual investigators receive a slightly smaller share of federal civilian academic research support than in the past, but still receive more than half of all such funds.
- R&D performance is highly concentrated in just a few States. California accounted for 20 percent of all R&D conducted in the United States, and 10 States represent over two-thirds of the national R&D total. This concentration of R&D funds has remained fairly constant over time, but many other States now are developing strategies to enhance their S&T base.

U.S. science and engineering investments and activities reflect changing national priorities.

- Health R&D accounts for a rapidly growing share (15 percent in 1994) of the government's total R&D investment. Much of the growth in health-related R&D is for AIDS research. National defense R&D spending still commands the lion's share (59 percent of the federal total), but is decreasing. Space research has increased, primarily for Space Station Freedom.
- Health research was scheduled to receive the single largest share—40 percent—of federal basic research budgets in 1994. General science, which included funding for the National Science Foundation and for the research portion of the now-canceled Superconducting Super Collider, accounted for 20 percent of estimated federal basic research authorizations. General science, however, still comprises only 4 percent of total federal R&D.
- Reflecting the overall strategy to use science and technology to achieve national goals, combined funding for six interagency cross-cutting initiatives equaled $12.5 billion, or about one-sixth of the estimated 1994 federal R&D support. Funding for biotechnology was $4.3 billion; advanced materials and processing, $2.1 billion; global change research, $1.5 billion; advanced manufacturing technology, $1.4 billion; and high-performance computing and communications, $1.0 billion. The science, mathematics, engineering, and technology education initiative was funded at $2.3 billion, although it is not directly included in an R&D budget. There is some overlap in these activities and budget estimates, and new federal strategic initiatives are being developed.

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> *"Results of academic research are much more useful to industry today than they were 10 or 20 years ago. Universities are more receptive to and interested in collaborating with industry at this time. However, academic research should focus its efforts on the long-term, fundamental needs of the United States in science and engineering, with input on those needs from private industry, government and other sectors."*
>
> CHARLES F. LARSEN
> Executive Director
> Industrial Research Institute

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The importance of supporting basic research in areas of strategic and national importance and the enhancement of interagency coordination are receiving increased national attention.

- Research can be directly influenced by the quest for fundamental knowledge and can contribute to strategic projects and/or national goals. Basic research and education are investments in future capabilities. It is therefore not surprising that the academic sector performed 62 percent of the Nation's basic research.

- In recognition of the importance of basic research, national expenditures in this area of investment increased both in terms of absolute levels of funding and as a proportion of total R&D expenditures. Since the mid-1980s, the share of R&D funding devoted to basic research rose from 13 to 16 percent. The Federal Government has traditionally funded the majority of the Nation's basic research; in 1993, it provided 63 percent of the funding for this activity.

- There is new and increased emphasis on supporting basic research in a variety of strategic areas as determined by the President, the new Cabinet-level National Science and Technology Council (NSTC),[1] and Congress.

- The NSTC will establish clear national goals for federal science and technology investments and ensure that science, space and technology policies and programs are developed and implemented to effectively contribute to those national goals. To enhance coordination of R&D strategies and budget recommendations, the National Science and Technology Council will establish coordinating committees on R&D in the following areas:
    - Health, Safety, and Food R&D
    - Fundamental Science and Engineering Research
    - Information and Communication R&D
    - Environment and Natural Resources Research
    - Civilian Industrial Technology R&D
    - Education and Training R&D
    - Transportation R&D
    - National Security R&D
    - International Science Engineering and Technology R&D

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[1] President Clinton established the National Science and Technology Council by Executive Order on November 23, 1993. The Council will consolidate the responsibilities previously carried out by a number of other interagency councils, including the Federal Coordinating Council for Science, Engineering, and Technology; the National Space Council; and the National Critical Materials Council. The same executive order also established the President's Committee of Advisors on Science and Technology; this private sector committee will serve as an advisory group to the President and the National Science and Technology Council.

Universities have assumed a larger role in performing the Nation's R&D, but are receiving a smaller share of their funding from the Federal Government.

- Academic R&D rose to an estimated $20.6 billion in 1993. Although overall expenditures have grown, the federal share of academic support has continued to decline, as other reported sources of university support—including universities' own funds—have grown more rapidly.
- In 1993, federal sources still provided the majority of funding for academic R&D—56 percent—but this was a decrease from the 68-percent share provided by the Federal Government in 1980. Academic institutions themselves provided the second largest share of academic R&D support, reaching 20 percent in 1993. Industrial support of academic research has grown more rapidly than support from other sources; its share increased from 3.9 percent in 1980 to 7.3 percent in 1993.
- The amount, adequacy, and condition of S&E research space at the Nation's research-performing institutions are all reported to have increased and/or improved between the 1988/89 and 1992/93 periods. However, 34 percent of the institutions still reported that their research space was inadequate.
- U.S. research universities have recently begun to show a decline in expenditures from current funds on academic R&D instrumentation after having made large increases in instrumentation investment during most of the 1980s.
- The rapid increase in the number of doctoral academic researchers evident in the 1980s appears to have leveled off for all fields but computer science.
- During the 1980s, a growing fraction of academic scientists and engineers reported being active in research. This trend seems to have slowed or leveled off between 1989 and 1991.

Defense downsizing has affected R&D expenditures and S&E employment.

- Defense R&D (which includes Department of Energy weapons programs) dropped to 59 percent of the 1994 federal R&D budget—down from its 1987 peak of 69 percent. Within the Department of Defense (DOD), however, the post-Cold War budget R&D funds have actually increased, while some other budget areas have declined. R&D now accounts for 14 percent of DOD's total outlays—up from a 10-percent share at the beginning of the defense buildup

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> ***"The burden of expectations on the universities grows year by year, while their traditional functions of teaching, research and extension have never been more important."***
>
> FRANK H. T. RHODES
> President of Cornell University

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in 1980. Out of its R&D budget, DOD now provides financing for a multi-agency defense conversion effort to bolster economic competitiveness and promote dual-use technologies to ease defense conversion.

- Federal funding of industrial R&D is highly concentrated in industries with defense importance; aircraft and missiles companies and communications equipment firms received more than three-fourths of federal R&D support to industry. R&D in these industries will no doubt be affected by downsizing of defense procurement.
- Defense downsizing has affected industry's employment of R&D scientists and engineers. Preliminary data show that the number of R&D scientists and engineers declined 6 percent, dropping from 730,000 in 1990 to 684,000 in 1992; in the aircraft and missiles industry, the number of federally supported R&D scientists and engineers declined 20 percent.
- Reduced defense spending is having a major impact on engineering employment. Recent government projections show that more than two out of five engineering defense-related civilian jobs have been, or will be, lost between 1987 and 1997.

R&D partnerships and university-industry cooperation are increasing.

- In constant dollars, academic R&D financed by industry increased an estimated 265 percent from 1980 to 1993. Industry's share of academic R&D funding grew from 3.9 percent to an estimated 7.3 percent.
- There was an estimated fourfold increase in the number of university-industry research centers (UIRCs) established in the 1980s compared to the number established in the 1970s. The more than 1,000 university-industry research centers in existence in 1991 spent an estimated $2.7 billion on R&D in 1990; 72 percent of the UIRCs were established with the support of federal or state funds.
- Industry-university coauthorship of scientific articles is increasing. In 1991, 35 percent of all industry articles were collaborative efforts with academic researchers, up from 22 percent a decade earlier.
- Academic patenting continued its rapid growth into 1991; almost one-fourth of all patents awarded to universities since 1969 were awarded in 1990-91. This increase was especially true in the health and biomedical-related areas and is one indicator of the potential

role played by academic R&D in the development of technology and new products. It may also be an indication of increased interest by university researchers in the marketplace.

- Universities are receiving financial benefits from patenting and licensing. A recent General Accounting Office study indicated that many universities expanded their efforts to transfer technology to industry and to enhance their licensing activities.
- Federal labs also are accelerating efforts to help industry make commercial use of their research. More than 1,500 cooperative R&D agreements (CRADAs) have been negotiated between federal labs and industry since 1987, and the number of licensing agreements has more than doubled.
- Eleven federal agencies participated in the Small Business Innovation Research (SBIR) Program in 1991, making awards totaling $483 million. During the 1983-91 period, more than one-fifth of these awards were computer-related, and one–fifth were for electronics research. Research in the life sciences and materials each represented 16 percent of all SBIR awards.

U.S. student performance in science and mathematics at the precollege level is still problematic.

- Increases in the average mathematics National Assessment of Educational Progress (NAEP) proficiency scores for 13- and 17-year-old students between 1978 and 1990 reflect gains among students who fall below the 50th percentile. The gains made by these students may be attributable to the past focus on teaching basic skills. Little or no progress has been made in raising the proficiency scores of students in the top quartiles.
- Research indicates that three-fourths of eventual science, mathematics, or engineering majors in college had different plans as high school sophomores or changed their minds several times during their academic careers. This finding suggests that educators concerned about the development of engineers, mathematicians, and scientists for the future need to look to other fields and help smooth the transition of students from one major to another.

There are major differences between males and females in their participation in science and engineering at all levels, but some improvements are evident.

- Although male and female students in the 4th, 8th, and 12th grades have equivalent mean NAEP scores in mathematics, more

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> *"If we can do a better job of educating all young people in science and mathematics, they will not only grow up with skills that will help them find jobs, they will be able to appreciate the importance of science and engineering and its role in the quality of life. Starting early is the best strategy, but we should not be shy in exploring every possible mechanism to reach all people of all ages."*
>
> NEAL LANE
> Director
> National Science Foundation

⁂

12th grade males than females are reaching the advanced and proficient levels. The science scores of 13- and 17-year-old male students have remained higher than those of female students of the same age.

- Females continue to be underrepresented among the highest scorers on the mathematics section of the Scholastic Aptitude Test (SAT). While 24 percent of males score at or above 600, only 13 percent of females score that high.
- At the undergraduate level, females obtained 45 percent of all bachelors degrees in the natural sciences in 1991. Their participation rate in engineering degrees grew from 2 to 16 percent between 1975 and 1991.
- By 1991, more than one-third of graduate S&E students were female.
- Females received half the social science degrees and over a quarter of the natural science degrees at the doctoral level in 1991. This represents a doubling of female participation rates in these S&E fields since 1975. However, women received relatively few engineering or math/computer sciences degrees at the doctoral level—9 and 17 percent, respectively.
- In 1991, women comprised 88 percent of all elementary school teachers and 56 percent of all secondary school teachers. However, women were less likely to be mathematics and science teachers.
- Although women still comprise a very small portion of the engineering workforce, some progress has been made over the past decade: Between 1983 and 1992, the percentage of women increased from 5.9 percent to 8.7 percent.
- The number of doctoral women scientists and engineers employed in academia more than doubled from 1979 to 1991, increasing from 16,650 to 35,600; the number active in academic R&D almost tripled.
- Women represented 19 percent of academic researchers in 1991. Almost half of these were active in the life sciences. Women accounted for only 3.4 percent of all academic doctoral engineers in 1991.

Minorities are still underrepresented in science, mathematics, and engineering, although some progress has been achieved.

- At a time when their numbers are growing, minority students are underrepresented among students doing well in mathematics and science and among those who go on to pursue math- and science-related careers. By 2010, the school-age population is expected to be more than 40-percent minority.
- From 1990 to 1992, NAEP mathematics proficiency scores showed gains for white students in all grades; the gains for black and Hispanic students were of a smaller magnitude.
- Approximately two-thirds of white and black students in high school have taken geometry or more advanced courses, compared to just over half of Hispanic students.
- The gap between the mathematics scores on the SAT of whites and Asians, on the one hand, and blacks, Mexican Americans, Latin Americans, Puerto Ricans, and Native Americans, on the other hand, is very large. While the overall performance of blacks has improved, there has been little progress in raising the number of high-scoring blacks.
- Asians have not only outscored all other groups on the mathematics portion of the SAT from 1987 to 1992, they also appear to be widening the gap between themselves and all other groups. The number of Asians scoring 750 or more doubled during the period.
- Underrepresented minorities (blacks, Hispanics, and Native Americans) modestly improved their participation rates in S&E degrees, rising from 6 percent in 1977 to almost 10 percent in 1991.
- Although 31 percent of the Nation's students come from minority groups, only 11 percent of high school mathematics teachers and only 4 percent of high school physics teachers are minorities.
- Eighth grade white and Asian students and eighth grade students from high socioeconomic status families were much more likely to be taught by mathematics teachers who majored in mathematics or mathematics education than were black, Hispanic, or Native American students.
- Undergraduate enrollments in engineering of blacks increased from 4 to 7 percent during the period 1979-92; concurrently, enrollments of Hispanics rose from 3 to 6 percent.
- Underrepresented minorities comprise only about 4.6 percent of the graduate student population in natural sciences and about 4 percent in engineering.

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> *"We are acutely sensitive to the underrepresentation of both women and minorities in science and engineering. Programs addressed to helping these groups to succeed and move into leadership roles are important. It will take time, but in the end that is the only way I think you are going to get really fundamental change, and that fundamental change is absolutely critical for our society right now."*
>
> JAMES J. DUDERSTADT
> Chairman
> National Science Board

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- The number of doctoral degrees obtained by underrepresented minorities has increased in all S&E fields, especially in the social and natural sciences. This growth is from a small base, however, and minority students still represent only a half of 1 percent of all doctoral degrees.
- Since 1979, increases in participation for minorities have been greater than for whites, but the overall number of black, Hispanic, and Native American researchers remains low. In 1991, minorities constituted 5 percent of academic doctoral S&E researchers, up from 2 percent in 1979. Their increasing share among researchers is roughly in line with their growing share of academic employment.
- Asians are increasingly prominent in academic R&D. They constituted 10 percent of academic researchers in 1991, up from 4 percent in 1979.
- Minorities are underrepresented in the engineering workforce. The percentage of blacks in the engineering workforce increased from 2.6 percent in 1983 to 4.0 percent in 1992, and the percentage of Hispanics increased from 2.2 to 3.1 percent over the same period.

Enrollments and degrees in S&E fields are up.

- There are indicators of growing interest among freshmen in studying fields of science and engineering. National Merit Scholars expressed increasing interest in natural science and engineering majors from 1989 to 1992.
- The absolute number of undergraduate degrees in engineering, math, and computer sciences continued to decline in 1991, but there was an upturn in natural science degrees in 1991 after a slow, decade-long decline.
- After declining slightly each year from 1982 to 1989, engineering enrollments have shown small increases since 1990. Women and minorities have primarily accounted for these increases.
- Graduate enrollments in S&E fields grew steadily at a rate of 2 percent per year from 1977 to 1991. Much of this growth was due to female and foreign students; by 1991, more than one-third of graduate S&E students were women and another quarter were foreign students.
- At the doctoral level, engineering degrees grew at a faster rate than any other field—6 percent annually since 1978, reaching over 5,000 degrees in 1991.

S&E personnel patterns are changing.

- U.S. industrial firms employed 1.3 million engineers and 667,000 scientists in 1992. Between 1989 and 1992, total industrial S&E employment increased at an average annual rate of 1.5 percent—considerably below the 3.6-percent rate registered during the preceding 9-year period.
- Current employment patterns for scientists and engineers show the stress of cutbacks in defense spending, industry downsizing, and the global economic slowdown. Although scientists and engineers are less likely to be unemployed than other types of workers, 1992 unemployment rates are higher than those recorded a few years ago. In 1992, the unemployment rate for engineers was 3.8 percent; for natural scientists, 2.3 percent; and for mathematical and computer scientists, 2.6 percent. In comparison, the overall national unemployment rate was 6.7 percent. Doctoral scientists, however, have an extremely low unemployment rate—1.5 percent in 1992.
- Organizations that track entry-level hiring of college graduates all report a reduction in recruiting by employers and in the number of job offers made to new college graduates in the 1990s. S&E graduates still appear to be faring better than those who majored in other disciplines and continue to command higher starting salaries than their counterparts in non-S&E fields.
- A nearly two-decade-long trend toward an aging academic research workforce is starting to reverse. "Young researchers" (that is, those who earned their doctoral degrees within the prior 7 years) comprised only 25 percent of all academic researchers in 1989, but accounted for 31 percent in 1991. The life and computer sciences have maintained relatively younger researcher pools throughout the period, while mathematics has apparently "aged" the most.
- Studies of the future S&E job market conducted by the Bureau of Labor Statistics yield the following conclusions for 1990-2005. These projections take defense downsizing into account.
  - Employment in technical occupations will grow at a faster pace than overall employment.
  - Employment in technology-intensive industries will grow at about the same rate as employment in general.

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"I don't think that the long-term future is bleak at all, because we are going to survive by virtue of our scientists and engineers, our people who have good heads on their shoulders and exercise their brains. At the same time . . . you can't cut your deficit and also hire more people . . . I'm sympathetic with the fact that there are enormous pressures in the job market."

JOHN GIBBONS
Director
Office of Science and Technology Policy

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- Surpluses are more likely to be observed in the S&E job market than shortages, but the latter—especially in specific fields—cannot be ruled out.

U.S. industrial R&D and technology remain competitive in some areas, but are being challenged by other nations.

- Industry is the largest performer of R&D in the United States. The estimated value of all R&D performed by companies in 1993 was $109.3 billion—or 68 percent of the total national R&D effort.

- R&D is highly concentrated in the United States: Eight industries account for over 80 percent of all industrial R&D performed in the country. The aircraft and communications equipment industries have consistently been the largest performers of R&D in the United States. The U.S. computer/office equipment industry—by virtue of higher rates of R&D performed over the past two decades—has taken over third place from the U.S. motor vehicle industry. In 1990, the top three R&D-performing industries in the United States—aircraft, communications equipment, and computer/office equipment—together accounted for over 50 percent of all industrial R&D performed.

- Since 1973, R&D performance in Japanese manufacturing industries grew at a higher annual rate than in the United States; since 1980, it grew faster than in all other industrialized countries. The top three R&D-performing industries in Japan—communications equipment, motor vehicles, and electrical machinery—accounted for about 40 percent of the Japanese national industrial R&D total. Rapid R&D growth in the Japanese computer/office equipment industry during the 1970s and 1980s has made that industry one of the country's top five industry performers.

- The United States continues to lead all other nations in the production of high-tech products. However, its leadership is being challenged by Japan, whose share of the global market for high-tech products steadily increased during the eighties and early nineties.

- Of the six industries that form the high-tech group, three U.S. industries—those producing scientific instruments, drugs and medicines, and aircraft—gained global market share during the 1980s and maintained that market share into the early 1990s.

- Demand for high-tech products in the United States was increasingly met by foreign suppliers during the 1980s and into the early 1990s. Import penetration of U.S. high-tech markets was deepest in the computer/office equipment industry.

- Japan's exports of high-tech products surpassed those of the United States and Germany in 1983 and continued to lead, by varying margins, through 1992. Japan led the world in exports of communications equipment, computer/office equipment, electrical machinery, and scientific instruments in 1992. The United States was the leading exporter in only one high-tech industry—aircraft.
- By the mid-1980s, U.S. high-tech exports failed to keep pace with U.S. imports of high-tech products, producing persistent annual trade deficits through 1992. Trade in computer/office equipment shows the greatest deficit among all the U.S. high-tech areas. Nevertheless, three of the six high-tech areas continue to show trade surpluses—aircraft, pharmaceuticals, and scientific instruments.

u.s. patenting activity has improved, but foreign inventors have important technical strengths.

- The number of U.S. patents granted to Americans has reversed its decline and has been increasing since 1983. Patent activity by foreign inventors in the United States generally followed the U.S. trend, although the number of foreign-origin patents increased somewhat faster after 1983.
- Americans successfully patent their inventions around the world. In 1990, countries in which U.S. inventors received more patents than other foreign inventors included Japan, the United Kingdom, Canada, Mexico, Brazil, and India.
- International patenting in three important technologies—robot technology, genetic engineering, and optical fiber technology—underscores the inventive activity of the United States, Japan, and Europe in these diverse areas. Based on an examination of national patenting activity in 33 countries during 1980-90, Japan and the United States led in overall technological activity in these areas.
- Foreign patenting activity in the United States is highly concentrated in a few countries. Inventors from the European Community and Japan account for 80 percent of all foreign-origin U.S. patents. Japanese inventors received 22 percent of all U.S. patents in 1991 and 46 percent of the foreign-origin patents in the United States. Newly industrialized economies, in particular Taiwan and South Korea, dramatically increased their patenting activity in the United States during the last half of the 1980s.

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> ***"One new idea leads to another, that to a third, and so on through a course of time until some one, with whom none of these was original, combines all together, and produces what is justly called a new invention."***
>
> THOMAS JEFFERSON

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◆ Recent patent emphases by foreign inventors in the United States show widespread international focus on several commercially important technologies. Japanese inventors are earning patents in the information technologies, as are German inventors. Also, German, French, and British inventors are showing high activity in biotechnology-related patent fields. Inventors from Taiwan and South Korea are earning an increasing number of U.S. patents in technology fields related to communications and electronic components.

Americans hold science and medicine in high regard, but do not consider themselves well-informed about science and technology.

◆ In 1992, approximately 80 percent of America adults believed that science and technology have increased our standard of living, enhanced our working conditions, and improved the public health. Throughout the last decade, at least 70 percent of Americans continued to express the view that the benefits of scientific research exceed risks or harms associated with that work.

◆ Compared to citizens in Japan and the European Community, a larger proportion of Americans expressed a high level of interest in new medical discoveries. Citizens in all three regions have about the same high level of interest in new scientific discoveries, the use of new inventions and technologies, and environmental pollution.

◆ Americans continue to have a high level of interest in science and technology. In 1992, about a third of Americans reported that they were very interested in issues about "new scientific discoveries" and "the use of new inventions and technologies."

◆ In contrast, in 1992, only about 12 percent of Americans thought of themselves as being very *well-informed* about issues involving new scientific discoveries, and 29 percent felt they were very well-informed about environmental pollution issues.

◆ A higher proportion of European adults than U.S. adults classify themselves as having a clear understanding of several important environmental concepts. For example, 44 percent of Europeans say they have a clear understanding of the hole in the ozone layer, compared to 30 percent of Americans.

◆ Most Americans depend on television and newspapers as their primary source of news and information. When looking for more specialized information, e.g., personal health information, a third of American adults rely on television.

- About 15 percent of Americans follow science and technology issues in the news and try to stay up to date on these matters.
- Americans show some awareness of the issues of integrity and fraud in scientific work, but they appear to take a reasonably balanced view of the problem. Additionally, American confidence in the leadership of the scientific community increased over the last few years and remains among the highest level for professional groups in American society.

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"Concern for man himself and his fate must always form the chief interest of all technical endeavors . . . Never forget this in the midst of your diagrams and equations."

ALBERT EINSTEIN

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Chapter 1

Elementary and Secondary Science and Mathematics Education

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HIGHLIGHTS

STUDENT ACHIEVEMENT: NAEP TRENDS

- **At a time when their numbers are growing, minority students are underrepresented among students doing well in mathematics and science and among those who go on to pursue mathematics- and science-related careers.** By the year 2010, the school-age population is expected to be more than 40 percent minority.

- **Increases in the average mathematics proficiency scores for 13- and 17-year-old students between 1978 and 1990 reflect gains among students who fall below the 50th percentile.** The gains made by these students may be attributable to the past focus on teaching basic skills. Little or no progress has been made in raising the proficiency scores of students in the top quartiles.

- **Recent trends (1990 to 1992) in mathematics proficiency scores show gains for white students in all grades,** while black and Hispanic students experienced fewer gains.

- **Male and female students in the 4th, 8th, and 12th grades have equivalent mean scores in mathematics.** However, more 12th grade males than females are reaching the advanced and proficient levels. The science scores of 13- and 17-year-old male students have remained higher than those of female students of the same age.

COURSETAKING

- **Approximately two-thirds of white and black students have taken geometry or more advanced courses,** compared to just over half of Hispanic students.

- **Research indicates that three-fourths of eventual science, mathematics, or engineering majors in college had different plans as high school sophomores or changed their minds several times during their academic careers.** This finding suggests that educators concerned about the development of engineers, mathematicians, and scientists for the future need to look to other fields and help smooth the transition of students from one major to another.

COLLEGE-BOUND STUDENTS: SAT TRENDS

- **Females continue to be underrepresented among the highest scorers on the mathematics section of the Scholastic Aptitude Test (SAT).** While 24 percent of males score at or above 600, only 13 percent of females score that high.

- **The gap between the mathematics scores on the SAT of whites and Asians, on the one hand, and black, Mexican Americans, Latin Americans, Puerto Ricans, and Native Americans, on the other hand, is very large.** While the overall performance of blacks has improved, there is little progress to report in raising the number of high-scoring blacks.

- **Asians have not only outscored all other groups on the mathematics portion of the SAT from 1987 to 1992, they appear to be widening the gap between themselves and all other groups.** The number of Asians scoring 750 or more doubled during the period.

INTERNATIONAL COMPARISONS

- **A longitudinal analysis of students who were tested in the earlier and later grades indicated that there was no evidence of improvement in the status of the U.S. students as they moved from 1st through 11th grade.** The researchers concluded that the achievement gap is real, that it is persistent, and that it is unlikely to diminish until, among other things, there are marked changes in the attitudes and beliefs of U.S. parents and students about education.

TEACHERS AND OTHER RESOURCES

- **In 1991, women comprised 88 percent of all elementary school teachers and 56 percent of all secondary school teachers.** However, women were less likely to be mathematics or science specialists in the elementary grades or mathematics and science teachers in the secondary grades.

- **The proportion of minority teachers of math and science is low relative to the proportion of minority students.** Although 31 percent of the Nation's students come from minority groups, only 11 percent of high school mathematics teachers and only 4 percent of high school physics teachers are minorities.

- **Eighth grade white and Asian students and eighth grade students from high socioeconomic status families** were much more likely to be taught by mathematics teachers who majored in mathematics or mathematics education than blacks, Hispanics, or Native Americans.

- **The use of computers and calculators in the classroom is on the rise.** Between 1985 and 1989 teachers' use of computers with their students more than doubled, although the number of teachers using computers for mathematics and science are still in the minority.

- **In a search for an explanation for racial/ethnic differences in school achievement, some researchers have pointed to the low level of peer support for academic excellence among black and Hispanic students.** Researchers continue to debate the causes of racial/ethnic differences in school achievement. However, any explanation must take the multiple and interactive influences of school, family, language, and community resources into account.

Introduction

Chapter Background

In 1945, the Harvard Committee on the Objectives of a General Education in a Free Society—a committee made up of some of the most distinguished scientists and educators in the country—echoed the conventional wisdom of the time when it recommended excluding half or more of the young people in the United States from advanced coursework in science and mathematics. The committee argued that "little more than half the pupils enrolled in the ninth grade can derive genuine profit from substantial instruction in algebra..." (Harvard Committee 1966).

In the ensuing half-century, attitudes (if not practice) have changed with regard to science and mathematics education at the precollegiate level. Today, reformers call for the popularization of high-level mathematics and science coursework; this reform movement is fueled by concerns over our Nation's economic competitiveness, the quality of our workforce, society's ability to cope with advanced technology, and the pipeline that produces the country's scientists and engineers. The calls for more instruction and higher achievement in mathematics and science for all students are also part of a larger trend of expansion and inclusion in U.S. education. Since World War II, access to public education has dramatically expanded, and the curriculum has diversified along with the student population.

Minority students are underrepresented among students doing well in mathematics and science and among those who go on to pursue math- and science-related careers. Yet the minority student population is growing dramatically. As of 1992, minorities made up over 30 percent of school-age youth (5 through 17 years). By 2010, the school-age population is expected to be more than 40 percent minority. After 2005, more blacks than non-Hispanic whites are projected to be added to the population each year. And, after 1995, the Hispanic population is projected to add more people to the United States every year than any other group (Day 1992).

Some States have already undergone the kind of rapid transformation into a diverse society expected for the rest of the country. In California, Louisiana, Hawaii, Mississippi, New Mexico, and Texas, whites currently represent less than 50 percent of the school-age population.

It is difficult to predict whether other recent social trends that have an effect on academic achievement will continue. However, increases in the number of children who speak a language other than English at home have already challenged the capacity of many schools to meet students' educational needs. Between 1980 and 1990 the number of children who spoke a language other than English at home grew from 10 to 14 percent of the 5- to 17-year-old population.

Increases in the number of children living in poverty also present schools with difficult challenges. Children living in poverty—particularly for an extended number of years—have generally performed less well on achievement tests and other measures of achievement than have children from more affluent families. Today, every sixth family with a child under 18 is poor (DOC 1992). There are more poor children in the United States today (14,341,000) than in any year since 1965 (Children's Defense Fund 1992). Many of those poor children are concentrated in big cities and rural states. For example, Detroit, Laredo (Texas), and New Orleans have child poverty rates above 46 percent. About one-third of all children in Mississippi and Louisiana live in poverty. Every other black preschooler in the country is poor, and two out of three preschoolers from any background are poor if they live in a female-headed family.

Raising the mathematics and science achievement of all groups is an important ingredient in meeting the challenges of the next century. This chapter on precollegiate mathematics and science education examines indicators of progress—or lack of progress. Unlike most previous *Science & Engineering Indicators* chapters on this topic (and, indeed, unlike other reports on education indicators), the present chapter focuses on the full distribution of achievement of *all* groups. Thus, the chapter explores trends among low-achieving and high-achieving students, not just mean scores.

Chapter Organization

The chapter begins with an examination of trends in academic achievement over time. It then explores trends in student persistence in mathematics and science courses, and trends in the academic achievement of college-bound students. Particular attention is paid to the performance of high-achieving students and those most likely to pursue degrees in science or mathematics. Next, the chapter includes a brief review of international comparisons of academic achievement. Whenever possible, the distribution of academic achievement is examined and the more complex story of how various groups of students are doing at all levels of achievement is told.

The chapter next presents data and issues on teachers and teaching. Included here is a discussion of questions about the supply, demand, and quality of science and mathematics teachers. International comparisons highlight characteristics of teachers and teaching that may be associated with higher science and mathematics achievement. An examination of curriculum and instruction issues follows, also using international comparisons to highlight effective practices. The section discusses the availability and use of resources as well as the discrepancies between common classroom practice and reform goals.

The chapter continues with an examination of out-of-school learning in mathematics and science. It then turns to an examination of the role of new testing instruments in improving precollegiate mathematics and science education, and concludes with a brief review of current policy initiatives.

Student Achievement

Although tests of mathematics and science achievement have been criticized for providing an incomplete picture of students' knowledge and skills (NCTM 1989),[1] they remain a primary indicator of the state of mathematics and science education.[2] This section examines results of the National Assessment of Educational Progress (NAEP) and re-analyzes trends in the distribution of achievement.

Several other indicators of student achievement are addressed in this section as well. The section examines how student persistence in science and mathematics courses, and student attitudes toward science and math, affect achievement. Next, Scholastic Aptitude Test (SAT) data are used to examine trends for students who intend to go to college. The section concludes with a discussion of recent international comparisons of achievement.

NAEP: An Indicator of Student Achievement

NAEP is the Federal Government's primary indicator of the Nation's educational achievement, and has been used to monitor student achievement in mathematics, science, reading, writing, and other subjects for nearly 20 years.[3] The NAEP tests are "low-stakes" ones: students are randomly selected for participation in NAEP testing, and their performance is not individually scored. (See "Student Motivation and NAEP Achievement.") The most recent mathematics NAEP was administered in 1992, and its results are reported on later in this section. The results from the 1990 assessments in mathematics and science tests allowed NAEP to perform a 17-year trend analysis in math, and a 20-year trend analysis in science (ETS 1991b.). The results of these trend analyses are discussed below.[4]

Trends in NAEP Mathematics and Science Test Achievement

Average Proficiency Scores. *Average mathematics proficiency scores* (see appendix table 1-9) for 9-year-old students experienced significant gains since the early 1970s. Scores for 9-year-old students remained stable in the 1970s and increased significantly (11 points) between 1982 and 1990. Scores for 13-year-olds improved slightly after 1978 to surpass the 1973 level; scores for 17-year-olds decreased between 1973 and 1982, and then by 1990, regained the ground they had lost.

Average proficiency scores in science (see appendix

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[1] Moreover, although test results do suggest some trends in the academic achievement of various groups of students, they only contribute a small amount of the information needed to guide improvement in mathematics and science education. For further discussion of this topic, see "Improvements in Assessing Achievement," at the end of this chapter.

[2] Because NAEP only tests students who are in school at ages 9, 13, and 17, caution is advised in interpreting the data. By age 17, blacks, Native Americans, and Hispanics drop out of school at a higher rate than do whites and Asians. The picture is further clouded by the fact that large numbers of Hispanic students, especially migrants, drop out as early as age 13. Also, because it is a "low-stakes" test, older students may not perform as well as they could on the NAEP tests.

The NAEP sample size is too small for a complete analysis of Native American, Asian, or the various groups within the Hispanic category. In addition, NAEP does not include much information about socioeconomic status. Despite these limitations, it is probably the best indicator of the mathematics and science achievement of U.S. students (Koretz 1991) because it uses a carefully selected random sample and is designed to represent what U.S. students are supposed to know.

[3] The mathematics NAEP was first conducted in 1972/73; it was then conducted every 4 years between 1977/78 and 1989/90, and the most recent math NAEP was administered in 1992. The science NAEP, which began in 1969/70, has followed the same schedule as the mathematics NAEP since 1982; it was not conducted in 1992.

The 1990 NAEP included a Trial State Assessment Program that assessed mathematics achievement of eighth grade public school students. Thirty-seven States plus the District of Columbia, Guam, and the U.S. Virgin Islands volunteered to participate in this program. The 1992 mathematics NAEP included a somewhat expanded state assessment component; this tested fourth and eighth grade students in 41 States plus the District of Columbia, Guam, and the U.S. Virgin Islands.

[4] The NAEP achievement scales range from 0 to 500 for both mathematics and science, but the scales are not equivalent. Within each subject, the scales permit comparison among groups, such as grades or demographic subgroups. The 1990 mathematics scale was computed using a weighted composite of proficiency on the five content area subscales: numbers and operations; measurement; geometry; data analysis, statistics, and probability; and algebra and functions (ETS 1991a). To help interpret the 0-500 point scale, NAEP developed characterizations of two scales—the 1990 mathematics scale and the trend scale—using proficiency levels which represent five anchor points on the 500-point scale (Research, Evaluation, and Dissemination Division 1993). The discussions in this chapter refer to the trend scale. The anchor descriptions can be found in appendix table 1-10.

The science scale was computed using a weighted composite of proficiency in the following four content area subscales: life sciences, physical sciences, earth and space sciences, and nature of science (NCES 1992e). To help interpret the 0 to 500 point scale for science, NAEP developed descriptions associated with each level that can be used as guides to performances typical of students at each level. The descriptions of these anchor points can be found in appendix table 1-12.

Student Motivation and NAEP Achievement

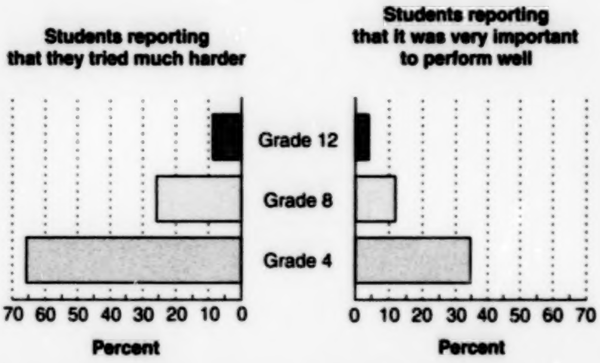
Because the NAEP tests are "low-stakes tests," some researchers have argued that the results do not yield an accurate picture of students' academic achievement. The 1992 NAEP mathematics assessment added a section of followup questions to try to determine student motivation for doing well on the test. (See figure 1-1.) In general, the data collected indicate that the scores of older students should be viewed with some caution, but overall the impact of any lack of motivation of NAEP test scores remains unknown.

Nearly half (45 percent) of grade 12 students and 20 percent of grade 8 students reported that they did not try as hard on the math NAEP test as they did on other math tests taken in school that year. In contrast, only 10 percent of grade 4 students reported not trying as hard. Similarly, 31 percent of grade 12 students and 13 percent of grade 8 students reported that it was not very important for them to perform well on the test, while only 4 percent of grade 4 students felt the same way.

Thus, a significant number of older students may not be motivated to do well on tests like NAEP, and their scores may reflect this lack of motivation. However, those 12th grade students who reported that they did not try as hard on the NAEP math test as they did on other math tests actually scored an average of 27 points higher than students who reported that they tried much harder and 21 points higher than students who reported that they tried harder than on other tests.

Although large numbers of older students reported a reduced effort, 55 percent of grade 12 students, 79 percent of grade 8 students, and 90 percent of grade 4 students reported that they tried at least as hard or harder on the NAEP math test compared with other math tests taken in school. Thus, while some students probably could have tried harder and scored higher, the majority of students reported making a reasonable effort.

Figure 1-1.
Students' reported effort and motivation on the NAEP math test



NOTE: Students were asked how hard they tried on the NAEP math test compared to other math tests taken that year in school. They were also asked how important they felt it was to perform well on the NAEP math test.

See appendix tables 1-1 and 1-2.

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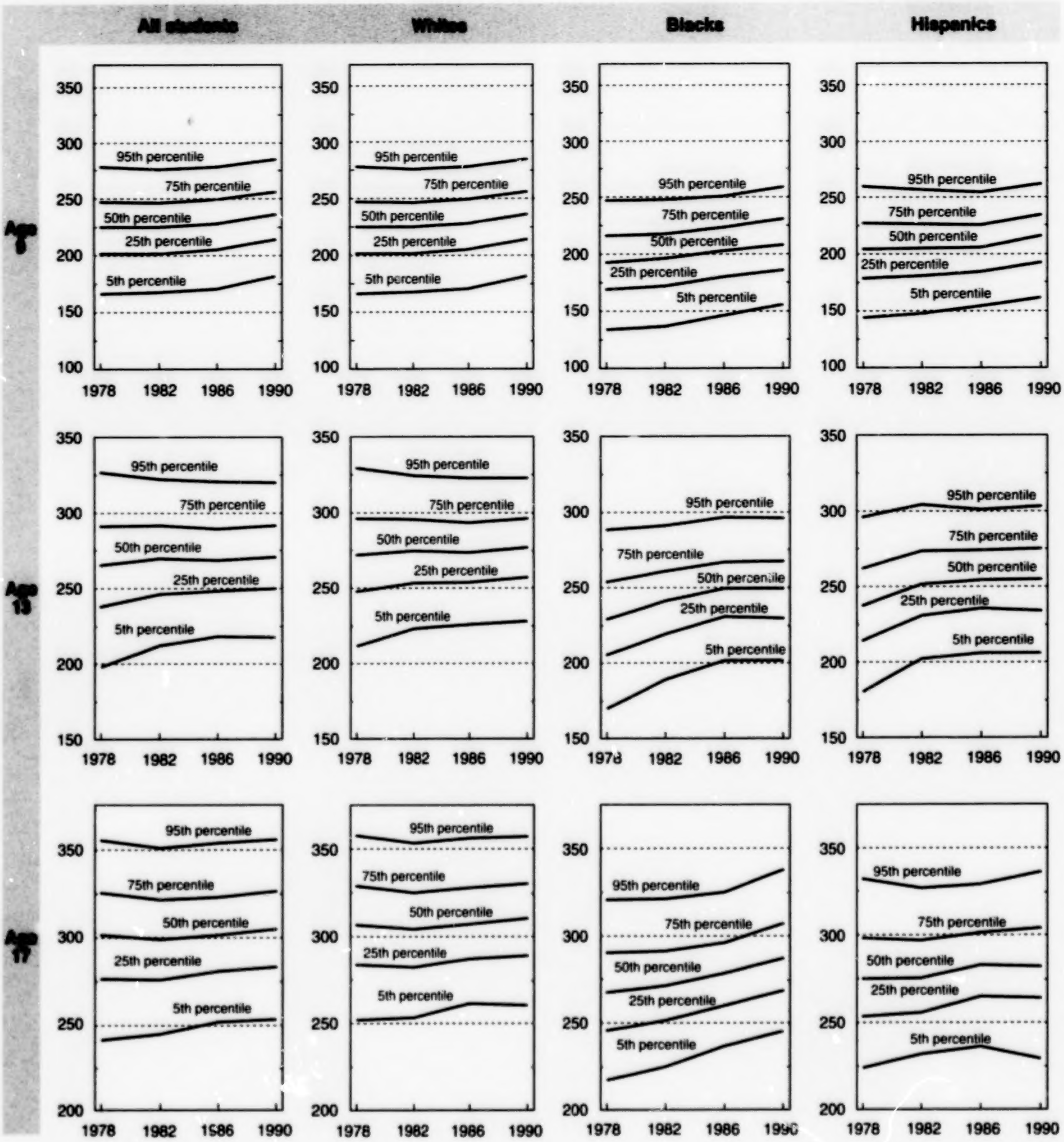
table 1-9) fell in the 1970s, then began to rise after 1977 for students at ages 9 and 13. By 1990, the average scores of students in both of these age groups had returned to their 1970 levels. Scores for students at age 17 continued to drop until 1982—a 22-point drop over the period—then regained some ground. Their scores in 1990 remained still significantly below the 1970 level (15 points).

Distributions of Average Proficiency Scores. Although average proficiency scores provide an overall picture of achievement trends since 1970 for science and since 1973 for mathematics, examining the trends across the distribution of students provides more information.

For all three age groups, average *mathematics proficiency scores* for students below the 50th percentile increased significantly more than for students above the 50th percentile between 1978 and 1990. For example, at age 17, the average for students in the 5th percentile increased by 12 points while the average score for students in the 95th percentile remained constant between 1978 and 1990. (See figure 1-2.) The differences for 13-year-old students are more dramatic. The average score for students in the 5th percentile increased by 20 points while the scores for the 95th percentile decreased by 7 points between 1978 and 1990. The differences for the youngest students are not as large. These trends indicate that the differences between the top and bottom students are narrowing somewhat (the difference remains at 102 points for 13- and 17-year-olds) and that any increases in the average mathematics proficiency scores for 13- and 17-year-old students are occurring among students who fall below the 50th percentile. The gains made by these students may be attributable to the past focus on teaching basic skills.

The distributions in *science proficiency scores* for age 9 and age 13 students are similar to those in mathematics, but the trends for 17-year-olds break the pattern. At age 9 and 13, the average score for students in the 5th percentile increased 16 and 17 points, respectively. Scores at the 95th percentile experienced little, if any, change between 1977 and 1990. The average scores for high school students (age 17) moved at the same rate across the distribution; the average score at each percentile

Figure 1-2.
Distribution of NAEP test scores: Mathematics



See appendix tables 1-3, 1-4, and 1-5.

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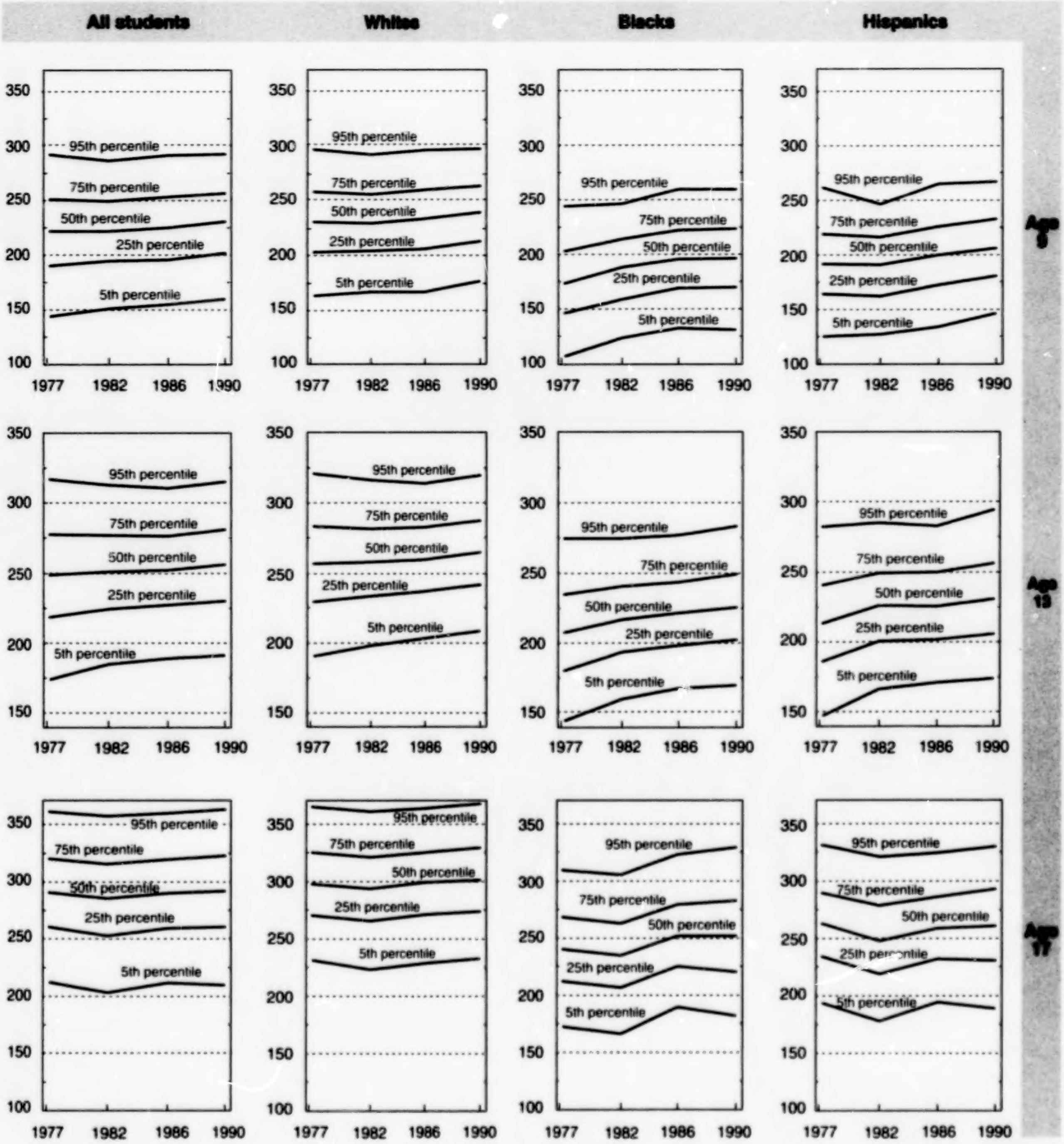
decreased until 1982, then slowly reached the initial 1977 level by 1990. (See figure 1-3.)

Proficiency Levels. The NAEP trend data also provide a look at shifts in the percentage of students who reach each proficiency level. (See appendix tables 1-10 and 1-12 for the mathematics and science proficiency level descriptions used through 1990.) In mathematics, students at age 17 have shifted slightly from lower to higher levels of mathematics. Between 1978 and 1990, fewer 17-year-old students scored only at level 200 where they were developing an understanding of addition and subtraction; a greater percentage of students demonstrated proficiency in the use of decimals, fractions, percents, geometric fig-

Figure 1-3.
Distribution of NAEP test scores: Science



See appendix tables 1-6, 1-7, and 1-8.

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ures, and graphs (level 300). However, the percentage of students who could solve problems in algebra and geometry did not change (level 350). In science, no real shifts occurred. (See appendix table 1–11.)

Trends in Achievement by Sex

Mathematics Proficiency Scores. The gap between males and females in mathematics scores at age 17, narrowing since 1973, has disappeared. (See appendix table 1-9.) Scores for both males and females at this age decreased in the 1970s and returned to the 1973 levels by 1990. Since 1973, no gap between 9- and 13-year-old males and females has existed and scores for both sexes have increased. Males and females at age 9 had the greatest gains (approximately 10 points each) and 13-year-old males gained 6 points. Only 13-year-old females made no real improvement over the 1973 scores.

Science Proficiency Scores. In science, the average proficiency scores for both sexes followed the trends of the overall population: declines in the 1970s followed by increases in the 1980s. At age 13, both males and females declined in the 1970s, but increased in the 1980s; for both sexes, the 1990 scores were about the same as in 1970. The gap between the sexes in science has been maintained since 1970 for 13- and 17-year-old students; only at age 9 is there no such gap. Although females have made gains since 1982, these were not sufficient to eliminate the score difference between the sexes.

Proficiency Levels. Males at age 17 have experienced no shifts from lower to higher levels of achievement in mathematics, but at age 13, they show a pronounced increase (approximately 10 percentage points) in the percentage that can use multiplication and division to solve problems (level 250). (See appendix tables 1-10 and 1-11.) A larger percentage of females at age 17 can use fractions and decimals (level 300) than could in 1978, but the proportion that could solve algebra and geometry problems (level 350) did not change. As with the males, the percentage of 13-year-old females who can use multiplication and division to solve problems (level 250) increased by nearly 10 percent.

In science, neither male nor female 17-year-olds experienced shifts from lower to higher levels of achievement. (See appendix tables 1-12 and 1-13.) However, a greater percentage of 13-year-olds of both sexes were able to apply and interpret general scientific information (level 250).

Trends in Achievement by Race/Ethnicity

Mathematics Proficiency Scores. Trends in mathematics proficiency scores show stability for white students and improvement for black and Hispanic students. Scores for black students have improved significantly (about 20 points) since 1973 for students at ages 9, 13, and 17. Younger Hispanic students (age 9 and 13) and white students (age 9) also experienced gains in their average mathematics proficiency scores while scores for the older students remained almost constant.

Science Proficiency Scores. The trends in science are less positive. Scores for white students declined for all age groups until 1982, then rebounded for the younger students (ages 9 and 13). Although scores for 17-year-old white students also increased after 1982, their scores remained significantly (11 points) below the 1970 level. Scores for black and Hispanic students at age 17 also declined until 1982 but returned to their original level. Only younger black and Hispanic students (age 9 for both and age 13 for Hispanic) experienced real growth over the 1970's scores. Although the average proficiency scores for minority 17-year-old students have been increasing in mathematics and have returned to the 1970 level in science, the gap between white and minority students in both subjects remains significant.

Distributions of Average Proficiency Scores. Each age and racial/ethnic group—except 17-year-old Hispanics—has experienced a narrowing in the gap between the highest and lowest achieving students in *mathematics*. (See figure 1-2.)

The most striking change occurs for black students. Blacks have large increases in average proficiency overall; this increase is especially noticeable among those students below the 50th percentile. Average scores for 13-year-old black students at the 5th percentile increased by 32 points since 1978, while scores at the 95th percentile showed no noticeable improvement (after accounting for standard error). For black students at ages 9 and 17, the differences in gains between the 5th and 95th percentiles were approximately 11 points each.

Scores for white students of all ages at the 5th percentile also grew more rapidly than scores for those at the 95th percentile. The most noteworthy example of this is for 13-year-olds, whose scores for the 5th percentile increased by 16 points, compared to a 7-point decrease for students at the 95th percentile.

The scores for Hispanic students varied little at age 17, with more striking gains for the 9- and 13-year-old age groups. The difference in gains between the 5th and 95th percentile for Hispanic 9-year-olds was 15 points; it was 19 points for 13-year-olds.

In *science*, as in mathematics, the most striking changes were for 13-year-old students. (See figure 1-3.) For black and Hispanic students, the gains for students at the 5th and 25th percentiles were the largest (26 and 21 points, respectively, for blacks; and 27 and 20 points, respectively, for Hispanics), compared to no gains at the 95th percentile and smaller gains (14 and 16 points, respectively) at the 75th percentile.[5] White students made large gains at the 5th (18 points) and 25th percentiles (12 points)—particularly when taking into consideration that there was only a 4-point gain at the 75th percentile and no real movement at the 95th percentile. The differences in the gains for top and bottom students at age 9 were also noteworthy, but the 17-year-old white and Hispanic students experienced no real change at any level in the distribution. Black 17-year-olds did not exhibit this trend: Their scores improved only at the 50th and 75th percentiles.[6]

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[5] Although there appears to be an 8-point gain for blacks and a 12-point gain for Hispanics at the 95th percentile, the standard errors are sufficiently large to prevent reporting these as real gains.

Proficiency Levels. Some shifts from lower to higher levels of proficiency are apparent when examining the percentage of students reaching each level of proficiency. (See appendix tables 1-10, 1-11, 1-12, and 1-13.) In *mathematics*, 13- and 17-year-old black students have experienced the largest shifts from accomplishing the basic mathematics tasks to accomplishing more intermediate tasks. The percentage of 13-year-old black students who can use multiplication and division to solve problems (level 250) increased from 26 percent in 1978 to 45 percent in 1990, and the number of 17-year-olds who can do the same increased by 5 percent. In addition, 15 percent more 17-year-old black students demonstrated proficiency in the use of decimals, fractions, percents, geometric figures, and graphs (level 300) compared to 6 percent more white students. The number of 13-year-old white and Hispanic students who can use multiplication and division to solve problems (level 250) increased by 10 and 18 points, respectively.

Reflecting the trends of the overall population, shifts in *science* were minimal at age 17. Slightly more black students were able to apply and interpret general scientific information (level 250); white and Hispanic students experienced no shifts. The percentages of Hispanic and black students who have the scientific knowledge to integrate scientific information and draw conclusions (level 350) remained low. At age 13, the shifts to higher levels of achievement were more pronounced: Each racial/ethnic group had a real shift in the percentage of students who could understand and apply general information from life and physical sciences (level 250).

Mathematics Achievement in 1992

Proficiency Versus Achievement Levels. The findings from the 1992 mathematics NAEP used some of the same assessment items as were used in 1990 to allow for measuring trends; additional assessment items were also developed to reflect improvements in the methods of assessing mathematical achievement.[7] Specifically, the 1992 assessment was expanded to include geometric manipulatives and questions requiring students to demonstrate—through writing and diagrams—their mathematical reasoning and problem-solving abilities. The 1992 definition of proficiency at each anchor level reflects this change in the assessment. (See appendix table 1-14.)

Data from the 1992 mathematics NAEP have also been analyzed in terms of newly established "achievement levels," or standards of student performance (NCES 1993d). The *proficiency* levels (in appendix table 1-14) describe what students know and can do; the *achievement* levels describe what students *should* know and *should* be able to do (NCES 1993c). The achievement levels were created by the National Assessment Governing Board in an attempt to characterize the student performance needed to attain basic, proficient ("solid academic achievement"), or advanced levels at grades 4, 8, and 12 (NCES 1993d). These levels are defined for each grade level in appendix tables 1-15, 1-16, and 1-17.

Overview of 1992 Achievement. Overall, average student *proficiency* increased at each grade level by 5 points between 1990 and 1992. The proportion of 4th grade students who performed at or above level 200 (addition, subtraction, and simple problem solving) and level 250 (multiplication, division, and simple measurement) increased by 5 percentage points; the percentage of 8th grade students who performed at or above level 300 (fractions, decimals, and percents) increased by 5 percentage points; and the percentage of 12th grade students who performed at or above levels 250 and 300 increased by 3 and 5 percentage points, respectively. No real movement occurred at the more advanced proficiency levels. (See appendix table 1-14.)

In terms of *achievement* levels, the number of students who scored below the basic level in 1990 declined by at least 5 percentage points at each grade. Concurrently, the percentage of students in 4th and 12th grades who achieved the basic—and in all grades who achieved the proficient level—increased. There was no change between 1990 and 1992 in the proportion of students who reached the advanced level. (See text table 1-1.)

Achievement by Sex. Mathematics performance by both male and female students at all grades increased by 4 to 6 points over the 1990 scores. These increases do not reflect an increase in the percentage of students reaching the advanced level. There was no movement in the percentage of 12th grade male or female students who reached any of the achievement levels. Eighth grade females and fourth grade males experienced an increase in the percent of students reaching the proficient level, and fourth grade males and females experienced an increase in the percent who reached the basic level. (See figure 1-4.)

A difference by sex for grade 12 does exist, with male students scoring higher than females. This difference does not extend to grades 4 or 8. More 12th grade males than females are reaching the advanced and proficient levels, but about the same percentages of 4th and 8th grade males and females are reaching the proficient level.

Achievement by Race/Ethnicity. The average proficiency scores for white students increased in all grades, and the percentage of whites reaching or surpassing basic and proficient levels increased for grades 4 and 8.

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[6] Although there appear to be large gains at the 5th, 25th, and 95th percentiles, the standard errors are sufficiently large to prevent reporting these as real gains.

[7] The 1992 NAEP was released in April 1993.

Text table 1–1.
National average mathematics proficiency score and achievement levels, by grade

Grade		Average score	Achievement level[1]			
			Advanced	Proficient	Basic	Below basic
			Percent			
4	1990	213	1	12	41	46
	1992	218	2	16	43	39
8	1990	263	2	18	38	42
	1992	268	4	21	38	37
12	1990	294	2	11	46	41
	1992	299	2	14	48	36

[1] Data are for the percentage who reached but did not surpass the given level.

See appendix tables 1-15, 1–16, and 1–17.

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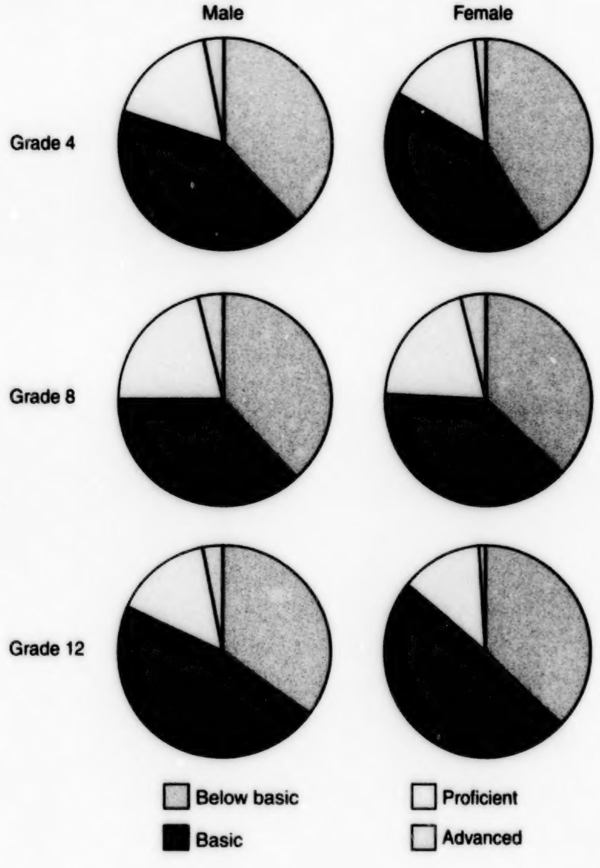
Minorities, on the other hand, experienced fewer gains: In fact, there was no real difference at all in minorities' proficiency scores or achievement levels for grades 4 and 8. However, there was a significant increase at grade 12 in average proficiency scores for Hispanic and black students: these increased 7 points each.

Few students from any racial/ethnic group reached the advanced level of achievement, but larger percentages of Asians and whites reached this level than of students in the other racial/ethnic groups. Although Asians and whites also reached the proficient level in greater numbers than did the other students, only among eighth grade Asians did the proportion of students scoring at this level rise above one-third. Relatively few (under 10 percent) of the students in the other racial/ethnic groups reached the proficient achievement level, while over 50 percent of these students scored below the basic level. (See appendix tables 1-15, 1-16, and 1-17.)

Figure 1-4.
Average achievement levels on the NAEP math test: 1992



See appendix tables 1-15 to 1-17.

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Student Persistence in Math and Science Courses[*]

Several studies have demonstrated a strong correlation between achievement scores and the number and level of courses taken. This correlation holds particularly true for science and math: The greater the number and the more advanced level of mathematics and science classes a student takes equates—on average—to higher scores on achievement tests. (See figure 1–5.) However, data from the NELS:88 first followup indicate that more advanced levels of coursetaking in mathematics may not *always* correlate to higher achievement levels. (See

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[*] The data in this section are taken from the Longitudinal Study of American Youth (LSAY) and the National Education Longitudinal Study of 1988 (NELS:88). Beginning in fall 1987, LSAY has collected data from approximately 3,000 7th and 3,000 10th grade students regarding their science and mathematics attitudes, achievement, and career plans. In addition to student achievement tests and attitudinal questionnaires, information has been collected each year from each student's mathematics and science teachers and from one parent. NELS:88 surveyed 24,599 students in grade 8 and their parents, teachers, and school administrators. The students were administered tests of their knowledge of eighth grade science and mathematics and other subjects. The sampled subjects are being followed every 2 years through college and beyond to learn about their progress in school, their aspirations, their employment, and factors that affect their ability to complete their education.

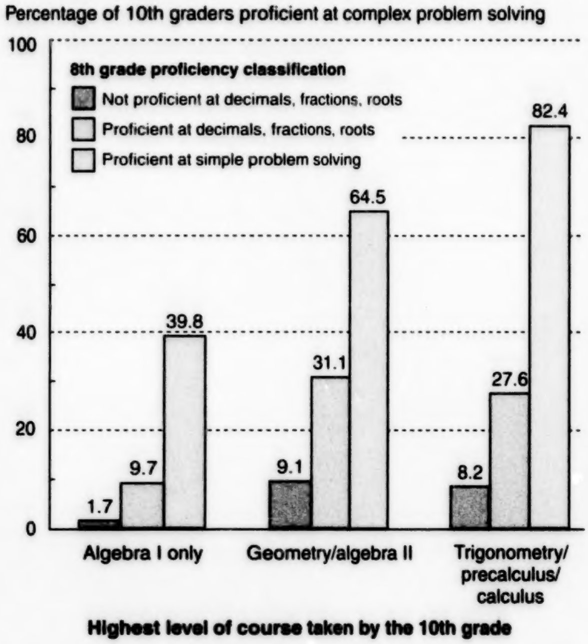
Math Coursetaking and Achievement: New Findings From NELS:88

Findings from the NELS:88 first followup survey indicate that advanced classes will only lead to improved achievement scores

- if students have a strong mathematical background, or
- if students are taking courses appropriate to their level of proficiency.

More specifically, the data[9] show that students who were *not* proficient at decimals, fractions, and roots in the 8th grade were equally likely by the 10th grade to be proficient on these items and on simple and complex problem solving regardless of whether they took geometry, algebra II, trigonometry or precalculus. Additionally, students who took these courses were five times more likely to be proficient in simple and complex problem solving than those who took only algebra I. On the other hand, students who were *already* proficient in simple problem solving in the eighth grade were significantly more likely to be proficient in advanced problem solving if they took trigonometry than if they took algebra I, geometry and/or algebra II. (See figure 1-5.)

Figure 1-5.
Percentage of 10th grade students who are proficient at complex problem solving, by 8th grade proficiency assessment and courses taken



SOURCE: National Center for Education Statistics, *Changes in Math Proficiency Between 8th and 10th grades* (Washington, D.C.: Department of Education, forthcoming).

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[9] Data on coursetaking is based on student reports of their coursetaking patterns. Some students may have misrepresented the courses they have taken due, in part, to changes in schedule, failing the course, or different course names.

"Math Coursetaking and Achievement: New Findings From NELS:88.")

According to the High School and Beyond Study of 1986,[10] mathematics was the subject most sensitive to school completion and further coursetaking (Secada 1992). And, according to the 1990 High School Transcript Study conducted by the National Center for Education Statistics, more students were taking more advanced courses in 1990 than in 1982. (See text table 1-2.)

According to a recent College Board study, geometry, the "gatekeeper" for college enrollment, was completed by 93 percent of college-bound seniors (NCES 1992b). However, of both college- and noncollege-bound seniors, approximately two-thirds completed a geometry course or above. Data from the 1990 NAEP indicated that, nationally, 67 percent of 17-year-olds had taken geometry or higher and fewer than 10 percent reported that they had taken precalculus or calculus (NCES 1992b). Findings from the 1990 High School Transcript Study corroborate these findings.

There is little difference between the percentages of white and black 17-year-old students who are taking these more advanced mathematics courses, and significantly fewer Hispanic students take the courses. Approximately two-thirds of white and black students have taken geometry or higher, compared to just over half of Hispanic students. However, the average achievement scores for white students are significantly (over 20 points) above both black and Hispanic students' average achievement scores. This may be due to the fact that white students are placed in higher level mathematics classes while in the middle schools so they have more opportunity to develop a strong background in mathematics. According to NELS:88 data, eighth grade minority students were placed in lower level mathematics classes at a rate much higher than their white peers. For example, black and Hispanic eighth grade students

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[10] The High School and Beyond Study is a national longitudinal survey conducted by the National Center for Education Statistics to capture changes in educational conditions, federal and state programs, students' school experiences, and future educational and occupational goals and plans. The study began in 1980 with a total of 58,270 students in grades 10 and 12; four followup studies (in 1982, 1984, 1986, and 1992) were subsequently completed. Survey instruments included student questionnaires with cognitive tests, school administrator and parent questionnaires, and a teacher comment checklist.

Text table 1–2.
Trends in mathematics coursetaking

Course	Student enrollment 1982	1987	1990
	Percent		
Algebra I	65	76	77
Algebra II	35	47	49
Geometry	46	61	65
Calculus	5	6	7

SOURCE: National Center for Education Statistics, 1990 High School Transcript Study, January 1993.

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Text table 1–3.
Trends in science coursetaking

Course	Student enrollment 1982	1987	1990
	Percent		
Biology	75	88	92
Chemistry	31	45	50
Physics	14	20	21

NOTE: Data represent percentage of 17-year-old students who have studied these subjects for 1 year or more.

SOURCE: National Center for Education Statistics, 1990 High School Transcript Study, January 1993.

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were nearly twice as likely as white students to be placed in remedial mathematics classes (NCES 1992f).

In science, enrollments in biology increased between 1982 and 1990 by 17 and 19 percent in chemistry. Ninety-two percent of graduates had taken biology, while 50 percent had taken chemistry. However, only 21 percent of graduates took physics. (See text table 1-3.) The coursetaking patterns differ little by sex, but there are differences by race/ethnicity. Only in physics does the pattern differ for males and females; a greater proportion of males than females have taken physics (25 and 18 percent, respectively). Asian graduates have taken chemistry and physics at a much higher rate than their counterparts (64 percent of Asians took chemistry, and 38 percent took physics). These were followed by white students (52 percent of whom took chemistry, and 23 percent of whom took physics). Approximately 40 percent of black and Hispanic students have taken chemistry by graduation, and fewer than 15 percent have taken physics.

Student Attitudes Toward Math and Science

Student attitudes toward mathematics and science—and their understanding of the relevance of these subjects to their future aspirations—affect students' enthusiasm for studying math and science, and help determine whether they will continue on to more advanced studies in these fields. (For a new perspective on this issue, see "Student SME Intentions Change Over Time.") In addition, counseling from teachers can determine whether students will take the more advanced courses.

One explanation of why so few students are taking advanced courses in science and math may be the low levels of students who think these courses are necessary for their planned careers. Relatively few students seem to understand the relationship between advanced math and science courses and careers in science, engineering, or the health professions. Data from the Longitudinal Study of American Youth (LSAY) show that in 1990, 28 percent of all seniors who were not enrolled in a mathematics or science course that semester did not feel that they needed advanced mathematics for what they plan to do in the future, and 39 percent of these seniors said they would not need advanced science.[11] In addition, approximately 30 percent of these students were advised by teachers and counselors that they did not need to take any more mathematics or science.

Even among students who expect to become scientists, the proportion who believe that advanced mathematics or science is necessary to their careers is below 75 percent. Of those 12th grade students who plan to become scientists, less than two-thirds said they needed specific advanced mathematics and science courses in high school. Slightly more students who planned to become engineers knew they needed the advanced mathematics and science courses. (See text table 1-4.)

Between 1978 and 1990, student beliefs regarding the relevance of mathematics and science coursework to their lives and careers changed only slightly. (See text table 1-5.) The proportion of 17-year-old students indicating that they would like to take more mathematics classes remained constant during this period, as did the proportion of 17-year-olds who felt they were good at this subject. Interestingly, among 13-year-olds, the proportion that wanted to take more math classes *decreased* by 7 percent, while the proportion that felt they were good at math *increased* by 6 percent (ETS 1991). The percentage of students indicating that they were taking mathematics "only because I have to" stayed the same for both age groups from 1978 to 1990. In science, over half of the 17-year-olds surveyed felt that what they learned in science classes is useful in everyday life; nearly two-thirds felt that what they learned in science classes will be useful in the future. These numbers were constant from 1978 to 1990.

Yet student attitudes toward mathematics and science are generally positive. The LSAY data indicate that most students enjoy studying mathematics and science as much as they do studying English and social studies. Students at all levels of coursework and achievement

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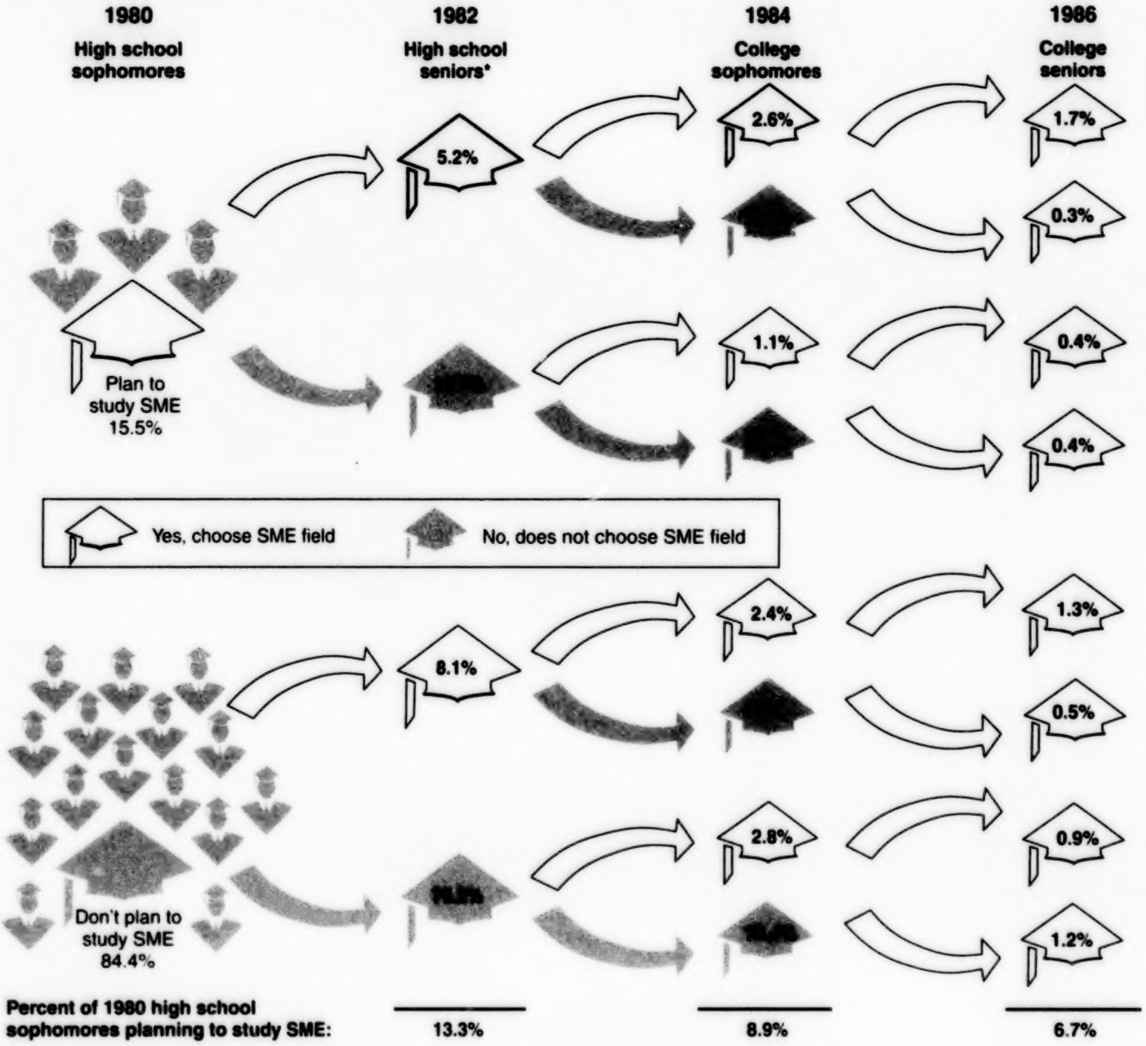
[11] See appendix tables 2-15 and 2-16 for more information on this point.

Student SME Intentions Change Over Time

Educators have long assumed that college students who major in science, mathematics, or engineering (SME) are made up of a core of students who became interested in these fields early on. However, data drawn from the 1986 third followup of the High School and Beyond 1980 sophomore cohort suggest that comparatively few students stay with their early interests. (See figure 1-6.) Only 18 percent of the high school sophomores who said in 1980 that they planned an SME major remained in SME by 1986. (Students who were sophomores in 1980 would, presumably, be college seniors by 1986 if they continued directly from high school through college.) Thus, 82 percent of SME majors had different plans as high school sophomores or changed their minds several times during their academic careers. Nearly 60 percent of those who eventually went on to major in SME had no plans to do so when they were high school sophomores. Indeed, nearly as many students decided to major in SME ***after*** their sophomore year of college as stayed with a decision to major in SME as high school sophomores. This finding suggests that educators concerned about the development of engineers, mathematicians, and scientists for the future need to look to other fields and help smooth the transition of students from one major to another.

Figure 1-6.
Percentage of 1980 high school sophomores who indicated in 1980, 1982, 1984, and 1986 whether they had plans to enter SME as their field of study



* Assumes that students continued their education without a gap.

NOTE: SME = Science, mathematics, or engineering.

SOURCE: T. B. Hoffer, "Career Choice Models Based on the High School and Beyond," paper presented at the annual meeting of the American Educational Research Association, April 1993.

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Text table 1–4.
High school seniors who feel they need advanced mathematics and science courses for a planned career in science or engineering

Course	Planning a career in Science	Planning a career in Engineering
	Percent	
Algebra	57	72
Geometry	49	71
Trigonometry	66	74
Calculus	52	78
Biology	59	26
Chemistry	57	58
Physics	63	81

SOURCES: J. D. Miller, et al., Longitudinal Study of American Youth Codebook (Dekalb, IL: Social Science Research Institute, Northern Illinois University, 1992); and unpublished tabulations.

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Text table 1–5.
Student attitudes toward mathematics and science

Statement		Agree or strongly agree Age 13	Agree or strongly agree Age 17
		Percent	
I would like to take more mathematics.	1978	50	39
	1990	43*	37
I am taking mathematics only because I have to.	1978	29	27
	1990	28	27
I am good at mathematics.	1978	65	54
	1990	71*	58
Much of what you learn in science classes is useful in everyday life.	1977	58	53
	1990	52*	52
Much of what you learn in science classes will be useful in the future.	1977	75	65
	1990	72	66

NOTE: *= statistically significant difference between 1977/78 and 1990.
SOURCE: Educational Testing Service, Trends in Academic Progress (Washington, DC: National Center for Education Statistics, 1991).

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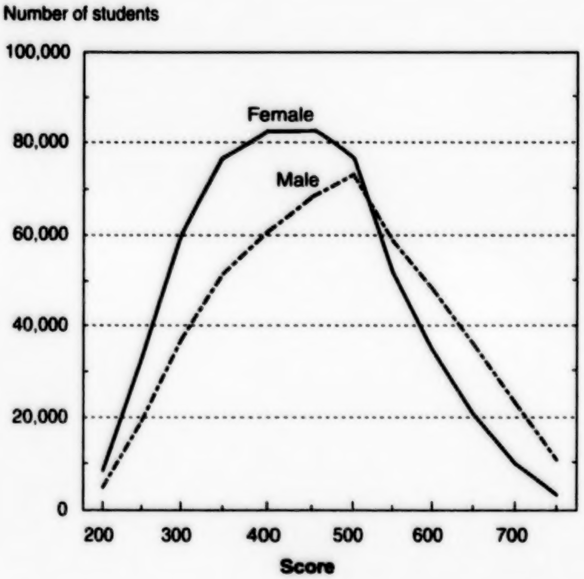
find mathematics and science courses to be much more challenging than English or social studies courses. The NELS:88 data show that over half (57 percent) of eighth grade students look forward to mathematics class, and 63 percent look forward to science class. Nearly 90 percent of these eighth graders felt that mathematics is important to their future, and 70 percent felt that science is important to their future.

Trends Among Higher Achieving Students: SAT Scores

The Scholastic Aptitude Test is taken by many college-bound seniors; as such, it measures the mathematics and verbal skills of the Nation's high-achieving students. The SAT is, however, a rather limited indicator of achievement. It measures a narrow range of academically oriented skills, does not test a national sample of students, and has been accused of being racially and sexually biased. Also, it is a multiple choice test; later in this chapter, the utility of such tests is challenged. (See "Improvements in Assessing Achievement.") Despite these concerns, the SAT scores have been shown to be a good predictor of students' college success. Test scores are better at predicting academic success at selective universities than any other criteria (Klitgaard 1984). SAT results are particularly useful predictors of success because they allow for examination of the full distribution of test-takers, as well as by such factors as race, sex, and socioeconomic status.

Scores by Sex. In 1992, more females than males took the SAT; however, the mean score for males was 43 points higher than that for females. (See figure 1-7.) In addition, females are underrepresented among the highest scorers. While 24 percent of males scored at or above 600 on the math SAT, only 13 percent of women scored that high. At first glance, this gap seems inconsistent with the smaller gaps found in the by-sex comparisons. In part, this difference may stem from the very nature of the tests themselves: NAEP identifies trends in academic progress, while the SAT predicts college performance.

Figure 1-7.
Distribution of math SAT scores, by sex: 1992



See appendix table 1-18. *Science & Engineering Indicators – 1993*

More importantly, NAEP does not ask questions requiring advanced mathematics skills and therefore does not differentiate among the highest achieving students. The SAT requires more advanced skills, but is still somewhat limited in its ability to disaggregate the highest scorers.

Although strong gains were evident in the NAEP mathematics scores and the sex gap seems to be closing, the significant gap among the highest scorers suggests that much more needs to be done if the full potential of half of the population is to be tapped.

Scores by Race/Ethnicity. While the gap in the SAT mathematics scores between males and females is significant, the gap between whites and Asians on the one hand, and blacks, Mexican Americans, Latin Americans, Puerto Ricans, and Native Americans on the other hand, is very large. A high percentage of Asian students scored extremely well on the math SAT in 1992. Black test-takers did not score particularly well as a group, with small numbers of high scorers and large numbers of low scorers. White test-takers' overall scores fell in between those of Asians and blacks.

Figure 1-8 shows 6-year trends in the distribution of SAT math scores and changes in the number of test-takers for each racial/ethnic group. In the case of whites, there was an overall decline in the number of test-takers and some declines in the proportion scoring between 250 and 450, as well as those scoring between 550 and 650. By contrast, the number of black test-takers increased, as did the number scoring between 300 and 500. Although the overall performance of blacks has improved, there has been little progress made toward raising the number of high-scoring blacks.

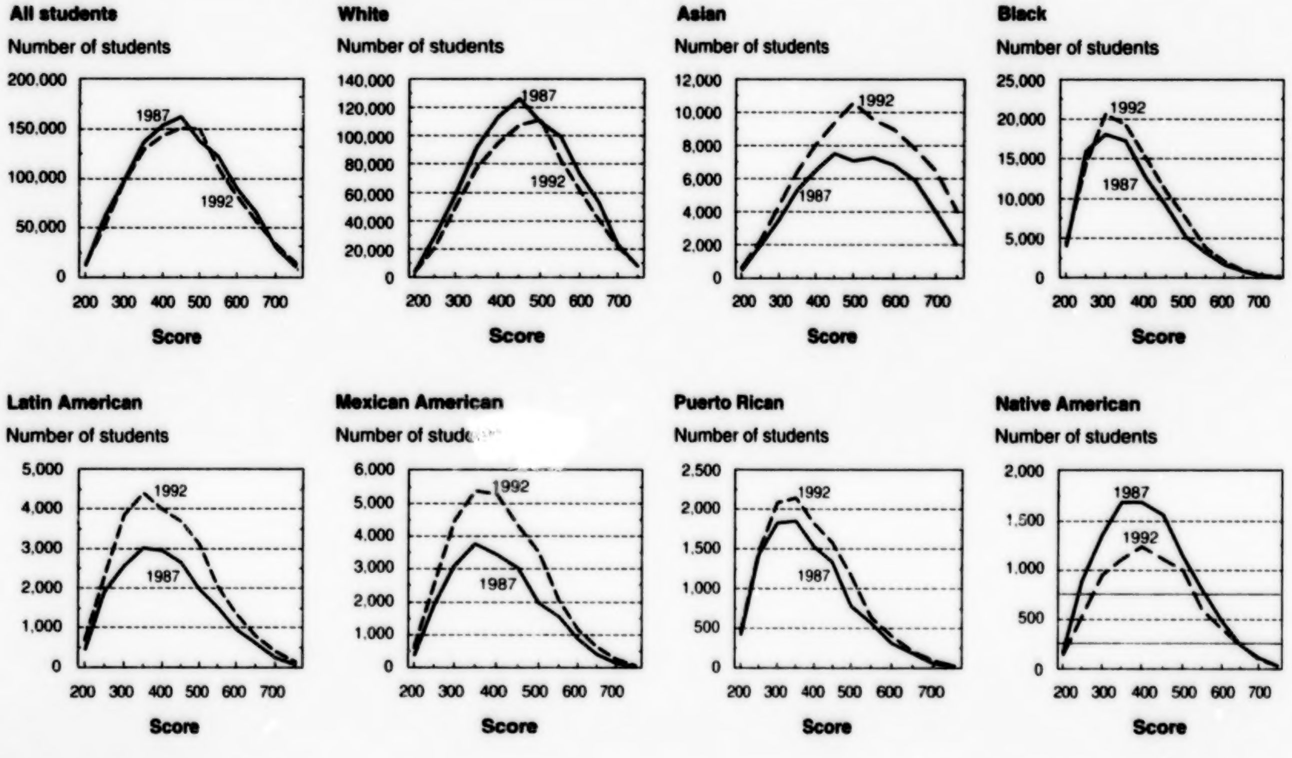
Asians not only outscored all other groups on the mathematics SAT from 1987 through 1992, they are also widening the gap between themselves and all other groups. More Asians are taking the test and are scoring at the highest levels. Indeed, the proportion of Asians scoring 750 or more almost doubled during the period, rising from 3 to 5 percent. At the same time, the percentage of Asians scoring below 450 dropped from 30 percent in 1987 to 27 percent in 1992.

Mexican Americans, Latin Americans, and Puerto Ricans all had increases in the number of test-takers. While all three groups continue to lag behind the national average, Latin Americans and Mexican Americans scored better than Puerto Ricans.

The decline in the number of Native Americans taking the SAT is of particular concern and warrants further investigation.

In comparing scores among the highest scoring students in each racial/ethnic group, certain patterns

Figure 1-8.
Distribution of SAT math scores, by race/ethnicity



See appendix tables 1-19 to 1-23.

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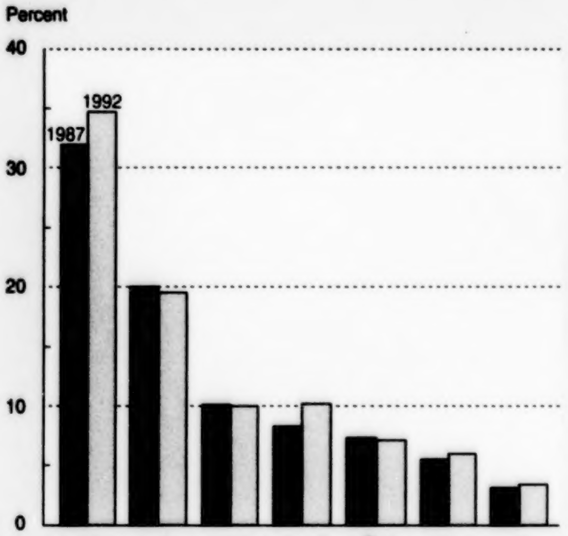
emerge. (See figure 1-9.) Large gaps exist between non-Asian minorities and whites; another gap is growing between Asians and all other groups. Given the Nation's ongoing demographic changes, these gaps among the highest scorers have important consequences for the pool of future U.S. scientists and engineers.

The total number of Asians scoring at high levels on the math SAT has increased dramatically—Asians have had a 46-percent increase in the number of students scoring above 600 on the mathematics SAT since 1987. By contrast, blacks had a 22-percent increase, and whites a 16-percent decrease, in the total number of test-takers scoring above 600. However, the slight increase in the percentages of blacks and Puerto Ricans scoring at or above 600 on the math SAT from 1987 to 1992—and the slight decline among whites, Mexican Americans, and Latin Americans—suggests a lack of progress in increasing the portion of U.S. students likely to be well-prepared for college-level work in mathematics or the sciences. Note that the 2-percentage point increase for Native Americans reflects a decline in the number of test-takers, rather than an increase in the number who scored at or above 600.

Engineering is a field that often attracts the Nation's top mathematics and science students. Therefore, students who indicate a planned major in engineering are likely to be top scorers on the mathematics SAT. Among students indicating that they intended to major in engineering, there were significant gaps in the mean SAT mathematics scores between whites and Asians, on the one hand, and between Native Americans, blacks, Mexican Americans, Puerto Ricans, and Latin Americans on the other hand. In addition, the mean score of Asian students intending to major in engineering increased more rapidly than that of any other group, moving them well ahead of whites and further widening the gap between them and the other racial/ethnic groups.

Figure 1-9.
Students who scored 600 or more on the math SAT



See appendix tables 1-19 to 1-23.

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International Comparisons of Achievement

Elementary- and secondary-age students in many industrialized Asian and European nations have consistently outperformed their U.S. peers in international mathematics and science tests. Despite the various data-related weaknesses that limit these international comparisons (Medrich and Griffith 1992), the results suggest that—at best—U.S. student performance on these tests has been relatively mediocre. Poor sample quality and student selectivity alone cannot explain the superior performances demonstrated by students in some countries (Bradburn, as cited in Rothman 1992). The consistency of the international findings, along with the magnitude of the differences in scores between the highest achieving countries and the United States, "suggests that there is an important underlying theme of lagging U.S. performance" (Medrich and Griffith 1992).

The 1981 Second International Mathematics Study (SIMS) and 1984 Second International Science Study (SISS), which measured mathematics achievement among 13-year-olds and science achievement among 10- and 14-year-olds, indicated large differences in the mean scores between the United States and the top-scoring countries. These studies also measured the mathematics and science achievement of students in their last year of secondary school; however, "meaningful comparisons of achievement are especially difficult for this group" (McKnight et al. 1989, p. 27) due to the sampling and selectivity problems that plague cross-national studies of the achievement of older students. Nevertheless, the relatively low performance of U.S. students was consistent across subject areas and age groups in both the SIMS and SISS; this was in keeping with the findings of the International Assessment of Educational Progress (Lapointe, Askew, and Mead 1992a) that was conducted among students representing a different set of countries and age groups.

IAEP 1991 Comparisons. The IAEP examined the mathematics and science achievement of 9- and 13-year-olds in 20 different countries.[12] However, any useful comparison of the achievement of students in these countries must take into consideration the various factors that may have contributed to apparent variations in achievement

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[12] These countries were Brazil, Canada, China, England, France, Hungary, Ireland, Israel, Italy, Jordon, Mozambique, Portugal, Scotland, Slovenia, South Korea, Soviet Union, Spain, Switzerland, Taiwan, and the United States.

Text table 1–6.
Percentage of items correct on the International Assessment of Educational Progress math and science tests: 1991

Country	9-year-olds		13-year-olds	
	Math	Science	Math	Science
	Percent			
Canada	60	63	62	69
France	—	—	64	69
Hungary	68	63	68	73
Ireland	60	57	61	63
Israel	64	61	63	70
Jordon	—	—	40	57
Scotland	—	—	61	68
Slovenia	56	58	57	70
South Korea	75	68	73	78
Spain	62	62	55	68
Taiwan	68	67	73	76
United States	58	65	55	67

SOURCE: A.E. Lapointe, J.M. Askew, and N. A. Mead, *Learning Mathematics* (Princeton: Educational Testing Service, 1992), and *Learning Science* (Princeton: Educational Testing Service, 1992).

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levels. These include the methodological limitations of the samples in some countries, low participation rates in others, and the differences among the nations in terms of their wealth and economic development—a particularly important element, given the strong positive correlation that exists between economic status and academic achievement (NSF 1992).

Text table 1-6 presents achievement data from only those countries that were most similar to the United States in terms of sample definitions and selection, participation rates, and economic status. Restricting the sample to these countries allows for a more meaningful analysis of comparative student achievement (NSF 1992).

Although the United States achieved near the levels of the South Koreans and Taiwanese in science at the 9-year-old level, they were unable to demonstrate this level of achievement at the 13-year-old level. As table 1-6 illustrates, U.S. students were outperformed by most of their international peers in both mathematics and science at the 13-year-old level, and in mathematics at the 9-year-old level.

Mathematics: Grades 1 and 5. Other, smaller international studies conducted over the past 10 years have found similar achievement trends among Asian and U.S. students.[13] In studies of first and fifth grade students in Minneapolis, Minnesota; Sendai, Japan; and Taipei, Taiwan;[14] U.S. students scored below their Japanese and Taiwanese peers in mathematics in 1980, 1984, and 1990 (Stevenson, Chen, and Lee 1993). (See figure 1-10.) The low levels of achievement in Minneapolis are of concern, because Minnesota students rank high among the States in mathematics achievement and Minnesota has the highest high school graduation rate in the country. Figure 1-10 illustrates the distribution of scores on the math test and includes comparisons between fifth grade Minneapolis students and students in Taipei (Taiwan), Sendai (Japan), and Szeged (Hungary).

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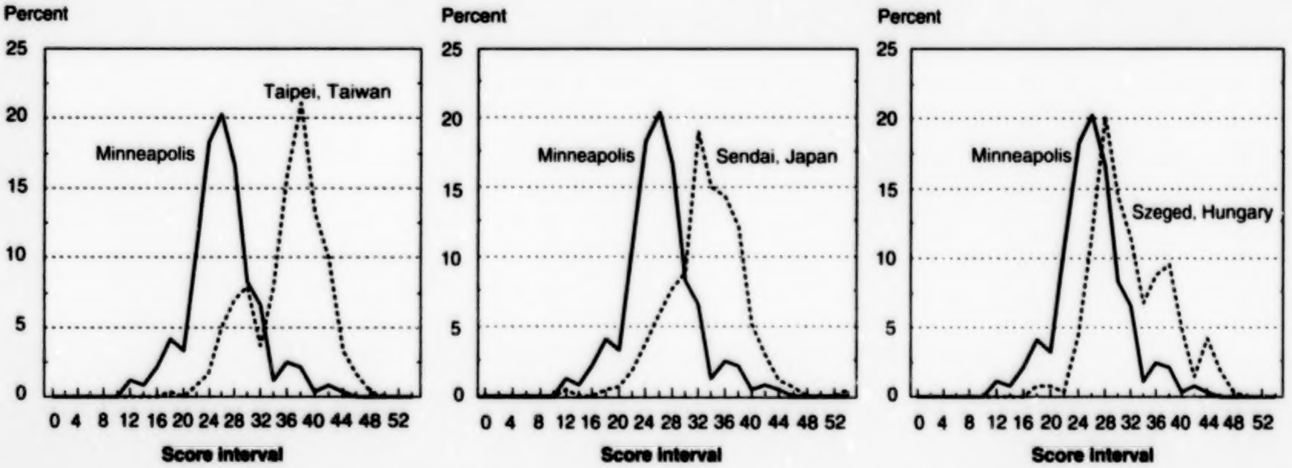
[13] These studies have generally taken specific steps to address the typical criticisms leveled against cross-national comparisons—e.g., that tests included items that students have not studied, or that student samples were not selected in identical ways across countries (Stevenson 1993).

[14] These cities were selected as "prototypic metropolitan areas" because nationwide sampling was not feasible due to financial and logistic constraints. In each city, the researchers selected a representative sample of the city's schools.

Figure 1-10.
Mathematics scores for grade 5 students in Minneapolis, Taipei, Sendai, and Szeged: 1990



SOURCE: H.W. Stevenson and S. Lee, "The Learning Gap Widens" (in preparation).

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Teachers and Teaching

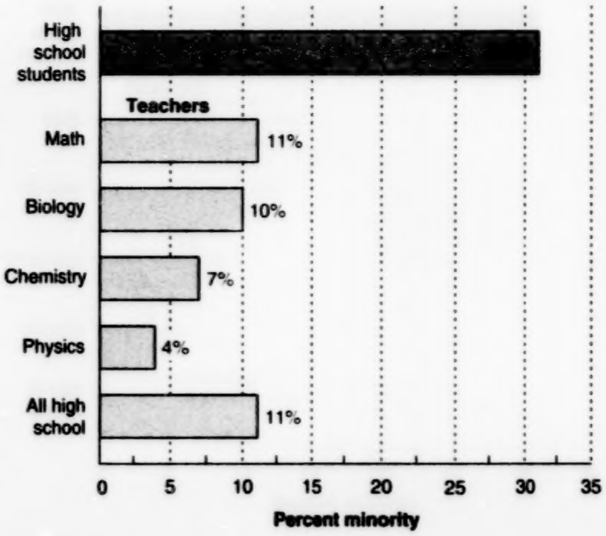
Teacher Characteristics

Although teachers are usually the focus of most discussions of school staffing, it is important to remember that the 2,630,000 U.S. teachers work with 103,000 principals, 86,000 guidance counselors, 79,000 librarians and media personnel, 109,000 other professionals, 408,000 teacher aides, and 498,000 other noninstructional personnel (NCES 1993b). Without minimizing the importance of these almost 1.3 million other people who directly participate in student education, this section focuses on the characteristics of the teaching force—particularly those of mathematics and science teachers.

Sex and Minority Status. In 1991, 88 percent of all elementary school teachers were women, as were 56 percent of all secondary school teachers (NEA 1992). Women were less likely to be mathematics or science specialists in the elementary grades or mathematics or science teachers in the secondary grades. (See figure 1-11.) At the secondary school level, women were more underrepresented among chemistry and physics teachers.

Minorities are also underrepresented among secondary school science teachers. Only 11 percent of high school math teachers, and only 4 percent of high school physics teachers, are minorities. (See figure 1-12.)[15]

Figure 1-12.
Percent minority for students and teachers in grades 9-12



NOTE: Data are for all teachers whose main or secondary assignment is in math or science.

SOURCES: (Teachers) State Departments of Education, Fall 1989; (Students) NCES, Schools and Staffing Survey, 1990-91. Council of Chief State School Officers, State Education Assessment Center, Washington, DC, 1993.

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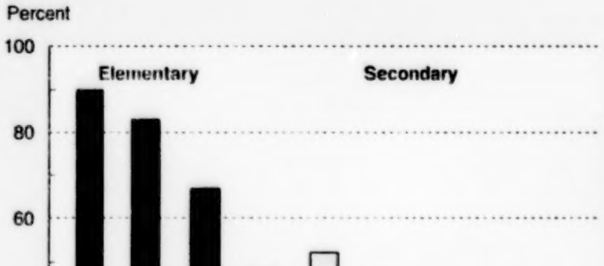
Figure 1-11.
Percent female of all teachers of math or science who teach those subjects as their main or secondary assignment: 1987-88



NOTE: Data are for all teachers whose main or secondary assignment is in math or science.

See appendix table 1-26. *Science & Engineering Indicators – 1993*

Education and Preparation. The combination of well-prepared teachers, effective curricula, supportive institutions, and motivated students is essential to improvement in mathematics and science achievement for all students. (See "Teacher Expertise and High Student Achievement.") Well-prepared teachers are those who have been drawn to the profession because of both commitment and talent, thoroughly trained in both pedagogy and the disciplines, and continually given opportunities for intellectual and professional growth. Unfortunately, this definition of the well-prepared teacher is frequently inconsistent with the qualifications and experience of most U.S. teachers.

About 60 percent of mathematics and science specialists at the elementary grades received their bachelors degrees in elementary education. (See appendix table 1-27.) Although course requirements vary at different higher education institutions, it is likely that those receiving degrees in elementary education were

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[15] For additional information on minority teachers, see appendix tables 1-24 and 1-25.

Teacher Expertise and High Student Achievement

Although teachers are key figures in improving mathematics and science learning, their expertise is only one of the many elements in the configuration of school, community, and family resources that affect student achievement. The by-state comparisons of the 1992 NAEP mathematics assessment illustrate the point.

Iowa students had the highest average NAEP math score in the country at grade 8 and the second highest average score at grade 4. Washington, D.C., students had the lowest average scores at both grades. Yet a higher percentage of the fourth and eighth grade teachers in Washington held advanced degrees and reported more hours of inservice training than did Iowa teachers. (Both groups of teachers reported about the same number of years of experience.) Also, Washington, D.C., teachers reportedly devoted more time to mathematics instruction per week and assigned more minutes of mathematics homework per day than did Iowa teachers.

required to take fewer math and science courses than those majoring in mathematics or science. Moreover, the mathematics and verbal SAT scores of college-bound seniors planning to major in education were significantly lower than the average scores of all students.[16] (See text table 1-7.)

Data suggest that the science and mathematics preparation of some middle school teachers is not strong. Only about 40 percent of grade 7-8 science teachers received their bachelors degrees in science or science education, and fewer than 40 percent of grade 7-8 mathematics teachers received their degree in either mathematics or mathematics education.

Among secondary school teachers, the percentage who taught in the field in which they were trained varied by subject area. (See appendix table 1-27.) While fewer than 20 percent of earth science teachers held subject matter degrees in their discipline, about 60 percent of biology teachers did so. Fewer than 40 percent of chemistry, physics, and mathematics teachers held subject matter degrees in their respective disciplines.

Poor and non-Asian minority students are more likely than other students to be taught by teachers who majored in education only or in a subject different from the one they teach. (See text table 1-8.) Eighth grade white, Asian, and high socioeconomic status students were much more likely to be taught math by teachers who majored in mathematics or mathematics education than were blacks, Hispanics, or Native Americans. Additionally, the qualifications of secondary mathematics and science teachers may differ depending on the racial composition of a school. Students attending schools with a high percentage of minority students are less likely to be taught by mathematics and science teachers with a masters degree, bach-elors degree, or certification in their assigned field. (See figure 1-13.)

International Comparisons of Teachers

In their studies of educational systems in the United States, Japan, Taiwan, and China, Stevenson and Stigler (1992) provide detailed descriptions of how teachers' pre- and in-service training, instructional practices, and working conditions differ between countries, and how these factors may contribute to variations in teacher effectiveness and student achievement.[17]

Professional Development. In general, teachers in the Asian countries surveyed have fewer years of formal

Text table 1–7.
Average SAT scores for students planning an education major

	Students planning an education major		All students	
	Verbal	Math	Verbal	Math
1982	394	419	426	467
1983	394	418	425	468
1984	398	425	426	471
1985	404	432	431	475
1986	NA	NA	430	476
1987	408	437	430	476
1988	407	442	428	476
1989	406	440	427	476
1990	406	442	424	476
1991	406	441	422	474

NA = not available

SOURCE: The College Board, *College-Bound Seniors: Profile of SAT and Achievement Test Takers*, annual series (Princeton: Educational Testing Service, 1982-91).

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[16] Although these scores should be considered with caution, it is not surprising that many of the most well-prepared college-bound students aspire to other fields. The starting salaries for new teachers remain significantly lower than those offered in many other fields. (See chapter 3.)

[17] For purposes of this discussion, data from China and Taiwan are not discussed separately.

Text table 1–8.
Proportion of eighth graders whose math teachers majored/minored in math: 1988

Student/school characteristic	Teacher: Major in math/math ed.	Teacher: Minor in math/math ed.	Teacher: Major in education	Teacher: Other major
	Percent			
All students	43.3	27.1	18.2	11.4
Race/ethnicity				
White	45.7	27.2	17.7	9.4
Asian	44.1	23.5	15.0	17.5
Black	40.0	26.6	21.5	12.9
Hispanic	33.3	28.5	17.5	20.8
Native American	30.5	23.5	23.4	22.6
Socioeconomic status				
Low	38.5	25.9	23.1	12.6
Middle	43.2	27.7	17.7	11.4
High	49.8	26.2	13.2	9.8

SOURCE: Research, Evaluation, and Dissemination Division, *Indicators of Science and Mathematics Education 1992*, NSF 93–95 (Washington, DC: National Science Foundation, 1993).

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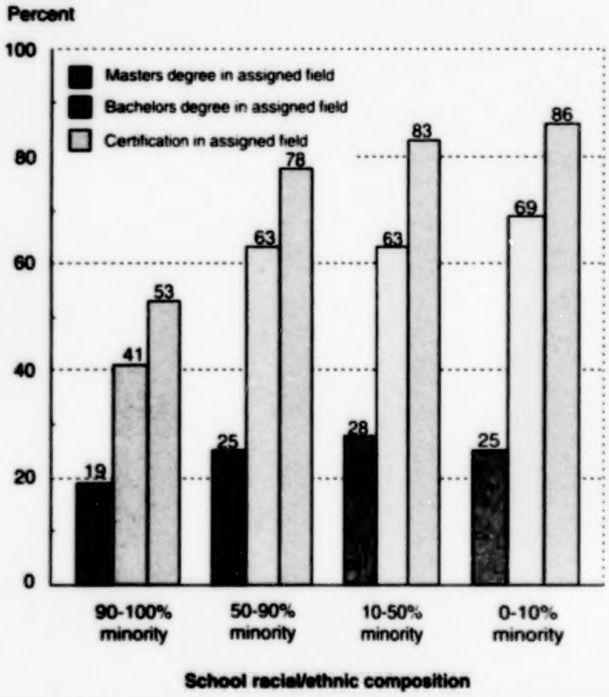
Figure 1-13.
Qualifications of secondary math and science teachers by school racial/ethnic composition



SOURCES: J. Oakes, *Multiplying Inequalities: The Effects of Race, Social Class, and Tracking on Opportunities to Learn Mathematics and Science*, (Santa Monica, CA: Rand, 1990), p. 61; and Council of Chief State School Officers, *State Indicators of Science and Mathematics Education 1993* (Washington, DC: 1993).

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education than do their U.S. counterparts. They are more likely to have majored in the liberal arts than in education, and generally have taken more courses in such substantive areas as mathematics, literature, etc., than have U.S. teachers, who take many more teaching methodology courses. While in the United States formal teacher training usually ends after a teaching certificate has been earned, "the real training of Asian teachers occurs in their on-the-job experience after graduating from college" (Stevenson and Stigler 1992, p. 159). Asian teachers receive much more extensive support and assistance from knowledgeable and skilled "master" teachers at their schools during their first few years in the classroom than do U.S. teachers, and a high level of interaction and communication among teachers typifies the experience of Asian teachers throughout their careers. For example, in Japan, meetings to discuss teaching techniques or to construct plans for specific lessons are frequently organized by school vice principals and head teachers; teachers also regularly observe their peers informally as they teach, offering encouragement as well as suggestions for improvement (Stevenson and Stigler 1992).

Working Conditions. Teacher schedules, the organization of the school day, and the physical structure of schools appear to contribute to the sense of professional isolation experienced by many U.S. teachers. Although Japanese and Chinese elementary school teachers have longer formal workdays, they teach fewer hours than do their U.S. peers (Stigler and Stevenson 1991). While most U.S. elementary school teachers prepare lessons and grade papers at home because their teaching responsibilities tend to prohibit their completing these duties during the day, Japanese and Chinese teachers use their nonteaching hours during the workday to not only grade papers, but also to prepare and discuss lessons with other teachers and share materials and techniques with them (Stevenson and Stigler 1991). Specially designated teacher rooms at each school, which are equipped with a desk for each teacher, facilitate Asian teachers' efforts to communicate with each other, and to provide and receive assistance as needed. In contrast, the physical structure of elementary schools in the United States, which often lack a common work area for teachers, creates few opportunities for regular teacher exchange (Sato and McLaughlin 1992).

Other features of the Chinese and Japanese education systems also help enhance teachers' working conditions. For example, to help avoid the "burnout" that may result from teaching the same subjects at the same grade level at the same school over an extended period of time, Japanese teachers follow the same group of students for two or three grades. Also, their teaching assignments are rotated, from grade to grade and school to school, in 3- to 7-year cycles (Stevenson and Stigler 1992). Professional advancement is also handled differently. In Japan, success as a classroom teacher is one of the primary requirements for advancement to a supervisory or administrative position; in the United States, coursework in educational administration is more strongly emphasized (Stevenson and Stigler 1992). Thus, U.S. teachers lack some of the motivation to enhance their teaching skills that their Asian counterparts enjoy.

Classroom Practices. In an attempt to understand the relatively poor performance of U.S. first and fifth graders in mathematics, Stigler and Stevenson (1991) examined how the subject is taught in classrooms in the Taipei, Taiwan; Sendai, Japan; Beijing, China; and Minneapolis and Chicago metropolitan areas. They observed differences in lesson coherency, classroom organization, teacher responses to academic diversity, use of real-world problems and objects, and teacher/student roles. Highlights of these findings are detailed below.

The researchers reported that classes in Japan and China were more coherent: Lessons had a clear beginning, middle, and conclusion, and instruction was rarely (less than 10 percent of the time) disrupted by irrelevant comments by teachers or by outsiders entering the room for some unrelated purpose. In contrast, in the United States, such interruptions occurred in 20 percent of the first grade classrooms, and 47 percent of the fifth grade classrooms studied (Stigler and Stevenson 1991). Coherence was also negatively affected by teachers shifting frequently from topic to topic during the course of a single lesson. Stigler and Stevenson report that "such changes in topic were responsible for 21 percent of the changes in segments that we observed in American classrooms but accounted for only 4 percent of the changes in segments in the Japanese classrooms" (p. 16). Asian teachers tended to introduce new activities and materials, rather than new topics, as a mean of holding students' attention throughout a lesson (Stigler and Stevenson 1991).

Asian teachers, who have greater amounts of nonteaching time during the day, use a portion of this time to work with individual students who are experiencing academic difficulties (Stigler and Stevenson 1991). During their regular classes, they focus instruction on the whole group without regard to academic differences and try to meet diverse academic needs by varying teaching techniques and materials. U.S. teachers, on the other hand, tend not to view whole-group instruction as well-suited to addressing diversity; they attempt to meet diverse student needs through individual instruction in the classroom (Stigler and Stevenson 1991).

The teaching techniques used in China and Japan are often recommended by U.S. educators as well. U.S. teachers do not have the same training and support as their Asian peers, and lack the time and opportunity provided to Asian teachers to hone their teaching skills. In addition, the heavy teaching load of U.S. elementary teachers further detracts from their ability to implement a well-planned lesson effectively (Stigler and Stevenson 1992).

Instructional Methods and Teaching Tools

Classroom Activities. Recent studies show that children learn from a variety of learning activities, including drills to strengthen basic skills and other activities to develop more complex reasoning capabilities. In recognition of this, the National Council of Teachers of Mathematics (NCTM) endorsed a new direction in teaching mathematics that de-emphasizes drill and practice and emphasizes goals of conceptual understanding and problem solving.

In the past, instruction focused almost exclusively on basic skills, which provided strong results on basic skills tests but may limit student proficiency in more advanced skills such as mathematical reasoning (Knapp, Shields, and Turnbull 1992). A 1992 study found that students who are exposed to instruction that emphasizes "meaning and understanding" score better on standardized tests of advanced academic skills than students who are in classrooms that emphasize arithmetic skills. The study also determined that the focus on meaning and understanding does not hinder proficiency in basic skills but instead facilitates proficiency in basic skills.

Currently, instruction in mathematics and science classrooms is moving slowly toward more student discussion and increased student involvement in the learning activities. ETS (1991) reported a significant increase between 1978 and 1990 in discussion opportunities for 17-year-olds in mathematics classes (51 to 63 percent). However, the percentage of students who make reports or do projects on mathematics was very low (5 percent).

Most students (approximately 85 percent) reported that they spend most of the time listening to the teacher explain mathematics lessons, watch the teachers work mathematics problems on the board, and take mathematics tests (NCES 1992b). Nearly 40 percent of students in eighth grade spend less than half of their time in mathematics classes in whole groups, indicating that these students are working in small groups or alone (NCES 1992f). (See figure 1-14.)

Science activities for elementary students are important because they stimulate student interest in science and provide a base for future science learning (Bybee and Landes 1990). Data from ETS (1991) show that the percentage of 9-year-old students who do scientific experiments has remained stable or decreased since 1977, but the percentage of students who have used thermometers and microscopes has increased. The proportion who use calculators remained stable (NCES 1992b). (See text table 1-9.)

At the higher grade levels, students do not participate in many science activities; the classes consist primarily of a teacher lecturing. ETS (1991) found that 61 percent of 8th grade students and 76 percent of 12th graders reported that their teachers lectured in science class several times a week or more. Fewer than half of these students reported that they were asked to do the following activities several times a week or more: asked about reasons for experimental results, to write an experiment, or are asked their opinion on science issues. More students participated in these activities once a week or less. (See figure 1-15.)

Text table 1–9.
Participation of 9-year-old students in science activities

Activity	1977	1990
	Percentage of students	
Experimented with living plants	70	64*
Experimented with batteries and bulbs	51	47
Used a thermometer	84	91*
Used a microscope	53	63*

NOTE: * = stastically significant difference between 1977 and 1990.
SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

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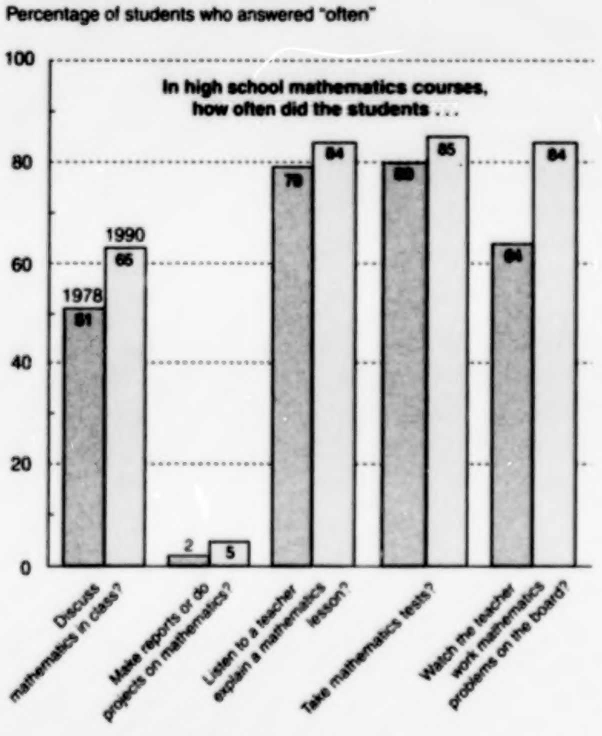
As part of its curriculum and instruction recommendations, NCTM suggested that the mathematics curriculum be updated to include technology such as computers and calculators in the classroom. NCTM recommends that

- appropriate calculators be available to all students at all times,
- every classroom have a computer for demonstration purposes,
- every student have access to a computer for individual and group work,
- all students learn to use the computer as a tool for processing information and performing calculations to investigate and solve problems, and
- students be able to understand when to use the various technologies for problem-solving (NCES 1992c).

Use of Computers.[18] The availability and use of computers in the classroom is on the rise. Since the early 1980s, the number of computers in schools has increased from approximately 50,000 to 2,400,000 in 1989. During this period, the way in which computers are used in school has changed. In 1983, when few computers were available, schools tried to provide a taste of computer experience to as many students as possible, without providing competence for any student. By 1985, schools had more computers, and teachers were using them to enhance their students' daily lessons. The computers were seldom used, however, to provide instruction in conventional school subjects. By 1989, computer

Figure 1-14.
Mathematics classroom activities as reported by 17-year-olds



SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

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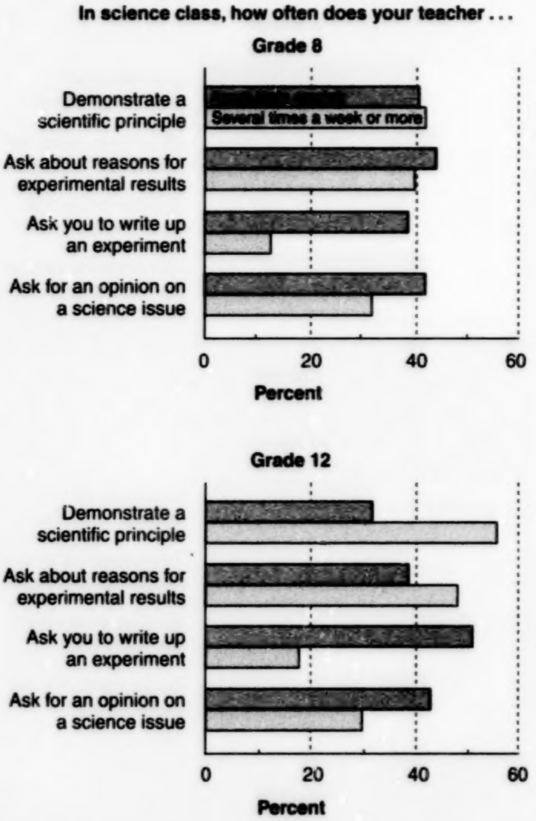
[18] The data in this section are from Becker (1991).

Figure 1-15.
Student reports on instructional approaches used in science class



SOURCE: National Center for Education Statistics, *The 1990 Science Report Card* (Washington, DC: U.S. Department of Education, 1992).

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laboratories were more common, and elementary school students were using computers to practice their basic skills. (See text table 1-10.)

The most current data indicate that students mostly use computers to learn computer-specific skills such as word processing or database programs. The use of computers is infrequent in mathematics and science classes compared with their use in computer classes; only 8 percent of mathematics and 5 percent of science class time was spent using computers. During the 1988/89 school year, 42 percent of all mathematics teachers and 36 percent of all science teachers said they used computers in at least one class; however, the computer instruction tends not to be integrated with subject matter.

ETS (1991) found that 34 percent of fourth grade and 21 percent of eighth grade students have computers available in their classrooms. An additional 47 percent of fourth grade and 52 percent of eighth grade students have computers available in the school, but they are difficult to access. These data indicate that fourth grade students use computers much more frequently than eighth grade students to solve mathematics problems. Only 12 percent of eighth grade students use computers for 30 minutes or more each week to solve mathematics problems compared to 41 percent of fourth graders. Almost three-quarters of eighth grade students do not use computers at all to solve mathematics problems in class compared to only 31 percent of fourth graders.

Use of Calculators. Students generally have access to calculators either at school or at home, yet this does not translate into increased calculator use in the schools. Although about half of all fourth and eighth grade students have access to school-owned calculators, only 3 percent of fourth graders and 19 percent of eighth graders are allowed to use these calculators in math class on a regular basis (NCES 1992c). Forty-seven percent of fourth graders and 22 percent of eighth graders have never been asked to use a calculator in math class. Twelfth grade students tend to use calculators more frequently than 4th and 8th. (See figure 1-16.) Over half (58 percent) of 12th graders said they use calculators at least several times a week, and 20 percent said they use them weekly. Nevertheless, only 44 percent of 8th graders and 30 percent of 12th graders were able to distinguish when to use a scientific calculator on most of the NAEP items designed for calculator use.

International Comparisons of Instructional Practices

Asian classes are larger than those in the United States and involve more direct instruction from teachers. Yet within this setting, Asian teachers incorporate high levels of student participation and problem solving. For example, teachers led students' activities 90 percent of the time in Taiwan, 74 percent of the time in Japan, and only 46 percent of the time in the United States; instruction was self-directed 9 percent of the time in Taiwan, 26 percent of the time in Japan, and 51 percent of the time in the United States.

Text table 1–10.
Availability and use of computers in grade 4 and 8 classrooms: 1990

Availability/use	Grade 4	Grade 8
Computers available in classroom	34	21
Computers available in school but difficult to access	47	52
Use computers 30 minutes or more each week to solve math problems	41	12
Do not use computers at all to solve math problems in class	31	73

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

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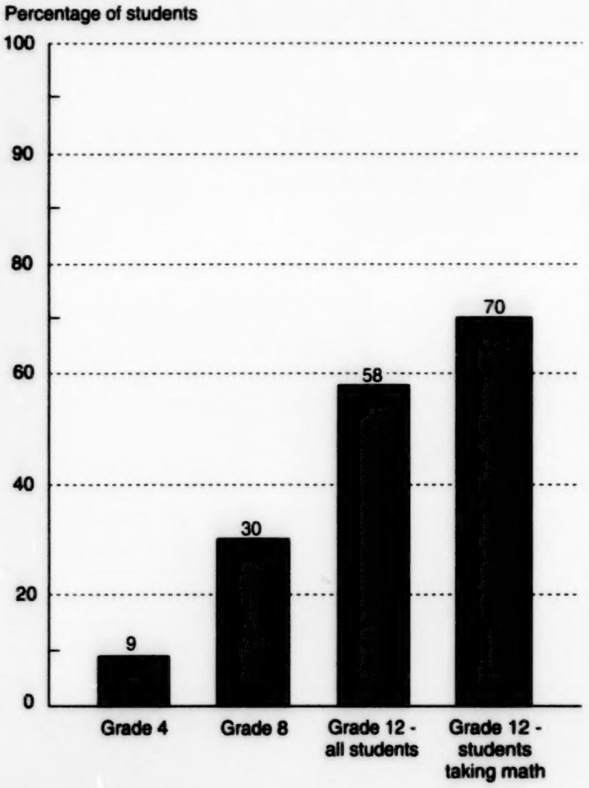
Figure 1-16.
Pecentage of students reporting using a calculator several times a week



SOURCE: National Center for Education Statistics, *The State of Mathematics Achievement*, (Washington, DC: Department of Education, 1991).

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U.S. students engaged in longer periods of desk work and practice than did their Asian peers: In nearly half of the fifth grade classes studied, this work was never evaluated or discussed (Stigler and Stevenson 1991). On the other hand, Asian teachers tended to lead more whole-class discussions and problem-solving exercises, pose more provocative and interesting questions, and intersperse the lessons with short periods of desk work that were evaluated or discussed in nearly all of the classrooms (Stigler and Stevenson 1991).

Asian elementary students are frequently required to discuss and evaluate the ideas and solutions that they and their classmates propose in mathematics classes, thus improving their individual understanding of and interest in mathematics and increasing the class's overall level of motivation (Stigler and Stevenson 1992). While there is a great deal of interaction between teachers and students in mathematics classes in the United States, the nature of the questions posed and answers given is quite different (Stigler and Stevenson 1992). Questions generally elicit very short answers, with an emphasis on "correctness" rather than on the thought processes involved. Also, while Chinese and Japanese teachers tended to view student errors as "an index of what still needs to be learned," U.S. teachers tended to interpret errors as "an indication of failure in learning the lesson" (Stigler and Stevenson 1992, p. 40).

Teachers' use of real-world problems and objects differ somewhat in Asian and U.S. classrooms. Although teachers in each country rely on the manipulation of concrete objects to teach mathematics to elementary students, teachers in the United States are less likely to use them (Stigler and Stevenson 1991). Those U.S. teachers who do use concrete objects tend to use a variety of different types as they teach different concepts—e.g., marbles to teach addition, and sticks to teach multiplication. Asian teachers tend to use the same objects to teach each topic as they believe that switching representations may confuse their students (Stigler and Stevenson 1991).

Beyond the Classroom: Students' Out-of-School Experiences

A student's activities and experiences outside of school may significantly enhance or hinder his or her academic success. A review of the research literature (Adelman et al. 1992) indicates, for example, that a family's socioeconomic status, culture, and/or behavioral patterns can all have a significant impact on the school achievement of its school-age members. In addition to the family, there are other individuals, organizations, and institutions that are able to provide specific learning opportunities, or encourage and provide examples of intellectually enhancing attitudes and behaviors; the extent to which an individual is willing, or able, to take advantage of these opportunities may have far-reaching and profound effects on his intellectual growth and development.

Parental Attitudes and Support

In their study of academic achievement among students in Minneapolis, Sendai, and Taipei, Stevenson, Chen, and Lee (1993) administered a test of students' general informational knowledge that would not normally have been acquired through regular schooling. Interestingly, the American students outperformed their Asian peers in kindergarten and the first grade. American superiority on the general information test continued to be evident through the 11th grade, although there was a narrowing of the achievement gap (Stevenson, Chen, and Lee 1993). The researchers concluded:

> "We attribute the early superiority of the American children to the greater cognitive stimulation provided by their parents, who indicated that they read more frequently to their young children, took them on more excursions, and accompanied them to more cultural events than did the Chinese or Japanese parents. As American children grow older, parents

> appear to be less likely to provide the kinds of enriched out-of-school experiences that they did before the children entered the first grade" (p. 55).

A study of the academic achievement of 536 school-age children from 200 Indochinese refugee families living in the United States (Caplan, Choy, and Whitmore 1992) further demonstrates the potential impact of family attitudes and behaviors. The students in grades K-12 who attended school in low-income metropolitan areas had remarkably high grade point averages (GPAs): 27 percent had an overall GPA in the A range, 52 percent in the B range, 17 percent in the C range, and 4 percent had a GPA below a C (Caplan, Choy, and Whitmore 1992).

The students' mathematics scores were even more impressive. Nearly half the students had GPAs equivalent to an A, while one-third earned a B. The results of standardized achievement tests showed similar levels of proficiency in mathematics. When compared nationally to students taking the California Achievement Test at equivalent grade levels, half of the Indochinese students scored in the top quartile; 27 percent scored in the top decile (Caplan, Choy, and Whitmore 1992).

The researchers identified several factors that appeared to be linked to the students' high levels of achievement. One factor was time spent on homework.[19] Whereas the Indochinese students spent an average of just over 3 hours on homework each day in high school, 2½ hours in junior high, and 2 hours in grade school, their American peers studied only 1½ hours each day in both junior high and high school. In addition to spending more time on their homework, the Indochinese students were more inclined to complete their homework with the assistance of siblings and other family members. Caplan, Choy, and Whitmore (1992) found that the older siblings learned as they tutored the younger ones, and the younger ones "learned how to learn," and also developed positive "skills, habits, attitudes and expectations"; they suggest that this may help explain the positive relationship between family size and GPA that was observed.

Other factors that were positively associated with academic achievement among the Indochinese families were (1) the presence of parents who read aloud to their children; (2) a belief in egalitarianism and role-sharing between male and female family members, and an absence of a pro-male bias; (3) the perception among family members that "learning and imparting knowledge" were pleasurable experiences; and (4) a retention of traditional, Indochinese cultural values—values that emphasize the importance of education, hard work, perseverance, and pride—by the family (Caplan, Choy, and Whitmore 1992). The researchers conclude that the American educational system is still able to educate students successfully—evidenced by the achievement of these refugee children—as long as it is not expected to also provide a host of needed social services and become "parent by proxy" to its students. They state:

> "We firmly believe that for American schools to succeed, parents and families must become more committed to the education of their children. They must instill a respect for education and create within the home an environment conducive to learning. They must also participate in the process so that their children feel comfortable learning and go to school willing and prepared to study" (p. 42).

For many students (e.g., those who are slower learners, or those whose socioeconomic status have resulted in limited exposure to challenging and stimulating information and materials at home or school), a supportive family is only part of what is needed to ensure their academic success. For them, nonschool hours represent a valuable opportunity to relearn, catch up, or extend their learning through enrichment programs that offer tutoring or mentoring services, or subject-specific training and enrichment (Adelman et al. 1992).

Tutoring and Mentoring

Tutoring programs have been very effective in improving students' GPAS, test scores, and overall academic performance, particularly in mathematics (Adelman et al. 1992). Studies also show that these positive outcomes also occur among groups of low-income, and racial/ethnic and language minority students (Herbst and Sontheimer 1987; Valenzuela-Smith, 1983; Kulik, and Kulik and Cohen, 1982). School-based tutoring programs have also been found to improve students' attitudes towards particular subjects and school in general, and they enhance the self-esteem and self-confidence of participants (Adelman et al. 1992 and Pringle et al. 1993).

Mentoring programs, which may include academic assistance, counseling, or social and recreational components, often focus on developing students' interests in particular professions or career fields (Adelman et al. 1992). In addition to receiving help with their schoolwork, high school participants in mentoring programs report learning about college life and engaging in career exploration activities; these experiences appear to motivate and improve participants' attitudes towards education (Adelman et al. 1992). These findings suggest that interest in mathematics and science careers among junior and senior high school students could be enhanced through similar efforts by professionals in the field.

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[19] The link between time spent on homework and school achievement, particularly for students in junior and senior high school, has been widely documented by other researchers in the field (Adelman et al. 1992). Nevertheless, all types of homework are not equally beneficial. For example, Cooper (1989) found preparation and practice homework integrating previous lessons to be more effective than homework restricted to current-day lesson content in junior and senior high mathematics classes. Other studies (Leone and Richards 1989; McDermott, Goldman, and Varenne 1984) also found evidence that family involvement can increase homework's effectiveness.

Extracurricular Activities

Current efforts to encourage mathematics and science achievement, particularly among females and minorities, include several academic enrichment programs that are held after school or during vacations. Programs such as the Gifted Math Program; the Mathematics, Engineering, and Science Achievement Program; and Creating Higher Aspirations and Motivations Program all seek to sharpen students' mathematics and science skills and heighten student interest in careers in these fields. Program activities include academic classes, specialized workshops, tutoring sessions, academic and university counseling, field trips, and/or employment programs.

The importance of maximizing students' out-of-school academic and nonacademic learning opportunities is widely recognized internationally. For example, in Japan, large numbers of low- and high-achieving students attend "Juku," where enrichment, remedial, and examination preparation classes are offered (Leestman et al. 1987). Although some Juku are viewed as "cram" schools where high school students prepare for entrance examinations to prestigious universities, other Juku offer nonacademic enrichment courses in music and the arts (Leestman et al. 1987).

Many studies suggest that nonacademic enrichment programs that emphasize overall youth development have the potential to contribute to the intellectual, social, physical, and emotional development of elementary- and secondary-age students (Adelman et al. 1992). In his study of school-based extracurricular programs in Hong Kong, Japan, Beijing, Singapore, and Taiwan, Stevenson (1993) describes the importance attached to such activities in these countries.

Extracurricular programs are offered during the regular school day, after school, or on weekends; often the entire student body is involved in one or more of the available activities. These activities include arts and crafts, music, sports, clubs and societies, public service opportunities, hobbies, and academics (Stevenson 1993). All activities are supported by school personnel, who believe that the programs help to stimulate an interest in learning, foster the development of various physical skills, promote positive social and cultural values and attitudes, and provide students with an opportunity to receive remedial help (Stevenson 1993).

A survey of community-based services for adolescents between the ages of 10 and 15 in the United Kingdom, Australia, Germany, Sweden, and Norway (Sherraden 1992), indicates that overall youth development is also of great importance and concern in Europe. Many nations use a percentage of educational or other public funds to support community-based youth development because they "recognize that formal schooling is not a sufficient format for individual education. There is too much to learn and schooling cannot cover all of it" (Sherraden 1992, p. 41).

In the United States, various youth organizations and school-related extracurricular programs have demonstrated an ability to meet these important needs (Adelman et al. 1992). In addition, many students actively seek to become involved in programs offered by sports leagues, museums, libraries, park and recreation departments, religious associations, and camping and outdoors organizations (Carnegie Council on Adolescent Development 1992).

Unfortunately, many low-income and minority youth in this country do not have access to the same range of services that their more affluent peers enjoy. The community-based services on which many rely are often underfunded and poorly equipped, and access to many national organizations are often available on a fee-for-service basis that they cannot afford (Carnegie Council for Adolescent Development 1992). Based on current anecdotal and statistical evidence, it appears that improving access to academic enrichment programs and other types of youth development opportunities is a worthy investment—an investment that is likely to enhance student interest in learning and their ability to achieve in school.

Improvements for the Future: Assessing Achievement and Revising Standards

Improvements in Assessing Achievement

The United States has relied upon standardized tests to evaluate learning because, in part, these tests are relatively inexpensive, easy to administer, and efficient in determining both individual and aggregate scores.[20] The most commonly used tests include the California Achievement Test, the Comprehensive Test of Basic Skills, the Iowa Test of Basic Skills, the Survey of Basic Skills of Science Research Associates, the Stanford Achievement Test, and the Metropolitan Achievement Test.

These tests, however, have met with skepticism and questions about their validity and comprehensiveness. Concerns raised about standardized tests include their

- emphasis on low-level thinking;
- inability to test process or method;
- inability to test depth of knowledge;
- inability to capture various levels of thinking (e.g., to award partial credit for a correct approach but a wrong final answer); and

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[20] This reliance has grown over the years. "Revenues from sales of tests used in elementary and secondary schools more than doubled (in constant dollars) between 1960 and 1989, a period during which student enrollments grew by only 15 percent" (OTA 1992, p. 3).

- tendency to lead teachers to "teach to the test" by emphasizing less advanced forms of learning in the curriculum.

This latter practice is particularly egregious when practiced by teachers of minority students. (See "Standardized Tests and Minority Students.")

According to one recent study funded by the National Science Foundation and conducted by the Center for the Study of Testing, Evaluation, and Educational Policy, teachers are dissatisfied with the standardized tests. Over 60 percent of 2,229 mathematics and science teachers in grades 4 through 12 surveyed felt that standardized tests negatively affected student learning. "The mandated testing caused narrowing and fragmenting of the curriculum, limited the nature of thinking, or forced them to rush too much for students to learn well" (Madaus et al. 1992, p. 16).

The study also found that the content covered by mathematics and science standardized tests was not well-balanced (Madaus et al. 1992, p. 16). The math tests emphasize number systems and theory, and minimize probability, algebraic thinking, measurement, and geometry. Similarly, the science tests emphasize life sciences and minimize physical sciences. The standardized mathematics tests ask questions demanding higher order thinking skills only 3 to 5 percent of the time (Madaus et al. 1992, p. 12). Only 8 percent of the standardized science test questions ask students to apply procedural skills toward problems and experiments; most do not stress application of knowledge.

Recently, there has been a good deal of activity among some organizations and in some states to design new assessment instruments. These new assessment tools are being designed to (1) track progress over time, (2) show how individuals learn, (3) assess educational programs, (4) indicate curriculum or teaching changes needed for improvement, and (5) inform policymakers about educational progress (Arter and Spandel 1991). These new tools will have to grapple with many of the problems discussed above.

Although there are some promising new approaches, test directors and researchers are concerned about quick implementation without sufficient investigation of the new tests' effects. Also, while the intention of the new assessment tools is to have them closely aligned to new, more demanding curriculum standards and better instruction practices, assessments are also expected to motivate students. Many are concerned that the same instruments cannot accomplish so many diverse tasks. Still, a number of new assessment approaches warrant continuing development.

Alternative forms of assessment to test students on higher order thinking skills and concept application rather than on rote memorization are now being developed. Some of these are discussed below.

Constructed Response Items. Constructed response test items are open-ended questions that ask students to derive and explain their answers. The format lends itself to more indepth assessment of higher order thinking, and it can be readily standardized and scored with relatively high validity levels. According to the Office of Technology Assessment (OTA 1992), constructed response items can be beneficial because they

- may be more similar to tasks that are familiar to students;
- may better reflect complex, real-world learning situations; and
- evoke answers that minimize student guessing and random answer selection.

Also, items can be scored so that students can get partial credit for partially correct answers. For these reasons, NAEP and some state assessment programs use constructed response items.

Performance-Based Assessments. This method of assessment asks students to "create an answer or product that demonstrates their knowledge or skills" (OTA 1992, p. 5). They may take the form of any number of tests that evaluate student performance including conducting experiments, answering open-response questions, computing mathematics equations, presenting an oral argument, writing an essay, and creating a portfolio of work accomplished throughout the school year. According to the Office of Technology Assessment (OTA 1992, p. 18), performance-based assessments generally

- allow students to create their own response rather than to choose between several already created answers;
- are criterion-referenced, or provide a standard according to which a student's work is evaluated rather than in comparison with other students;
- concentrate on the problem-solving process rather than on just obtaining the correct answer; and
- require that trained teachers or others carefully evaluate the assessments and provide consistency across scorers.

Performance-based assessment has been gaining support as an alternative or supplement to traditional standardized tests. Proponents suggest that performance assessments more closely link assessment and instruction, more accurately measure the mathematic and scientific skills and knowledge advocated by the NCTM standards, and allow a more complete account of student academic development. By December 1992, 13 States reported implementing some sort of performance-based assessment, while 28 others reported planning or piloting stages of performance assessments (Pechman and Laguarda 1993).

Standardized Tests and Minority Students

Researchers have found that standardized tests are particularly harmful to minority students. For example, Lomax et al. (1992) report:

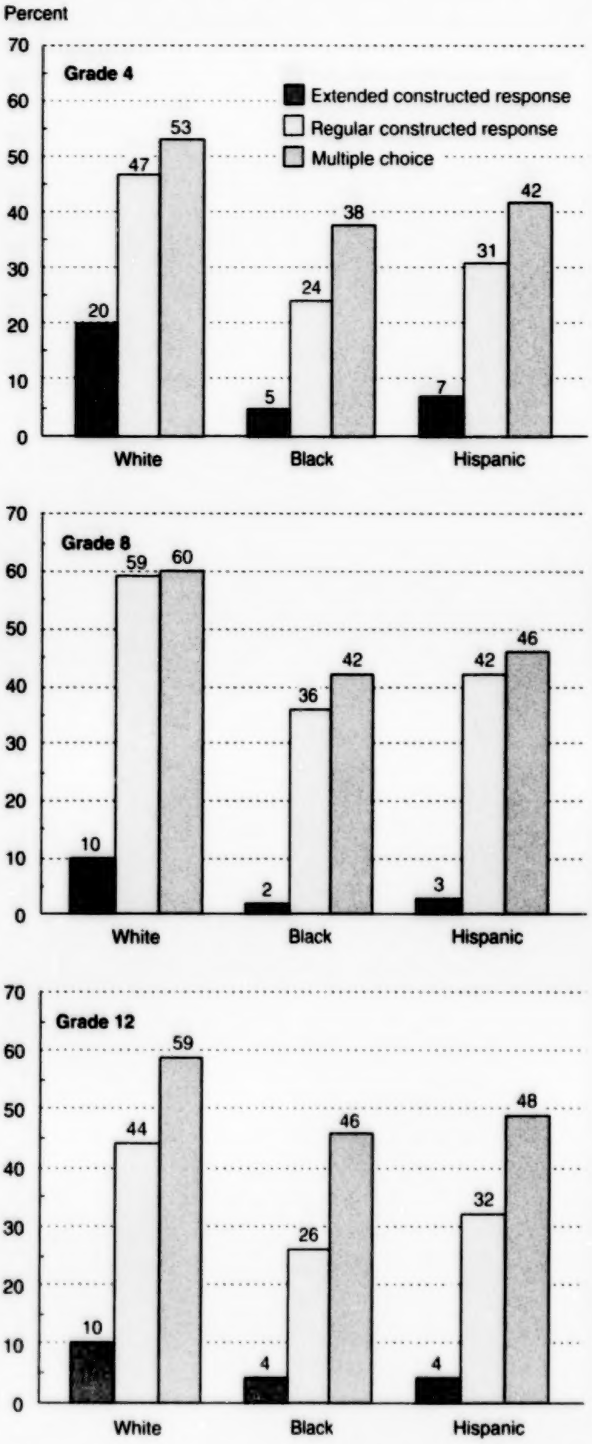
> Minority classes are receiving less quality instruction in these content areas in favor of more instruction to prepare for the mandated test ... In addition, these standardized tests reflect low level conceptual knowledge, low level thinking, and a lack of procedural knowledge in science, with an over-emphasis on algorithms and formulae in mathematics. Such tests are driving instruction, particularly for minority students (p. 15).

Recently released results from the 1992 NAEP mathematics assessments lend support to this position. The 1992 NAEP measured student performance on three types of questions:

- multiple choice questions;
- regular constructed response questions, which require relatively short answers of a few sentences each; and
- extended constructed response questions, which require deeper thought and more elaborate responses.

Figure 1-17 suggests that the gap between whites and blacks and Hispanics is large when responses to the more challenging types of questions are compared. For example, at the eighth grade level, whites correctly answered 60 percent of multiple choice questions, 59 percent of regular constructed response questions, and 10 percent of extended constructed response questions. Blacks correctly answered 42 percent of multiple choice questions, 36 percent of regular constructed response questions, and 2 percent of extended constructed response questions.

Figure 1-17.
Average percentage correct on each type of NAEP mathematics question: 1992



SOURCE: National Center for Education Statistics, *Data Compendium for the NAEP 1992. Mathematics Assessment of the Nation and the States* (Washington, DC: Government Printing Office, 1993).

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One form of performance-based assessment is ***portfolio assessment***. Students compile and submit a collection of work in a specific subject area completed during a given period of time. Supporters argue that portfolios encourage students to work to their best abilities and constantly improve their work. According to Arter and Spandel (1991), portfolios can

- provide a more complete picture of student ability by incorporating measures such as motivation and persistence;
- capture students' thought processes;
- share with students the basis upon which they are judged, and thus align expectations and performance with assessment; and
- display a chronological development of student progress.

However, while the portfolio method is useful for determining ***aggregate*** success, a recent study reports a significant lack of consistency between portfolio scorers—a lack great enough to draw the method's use into question as a reliable indicator of ***individual*** success (Koretz et al. 1992). This study suggests a need for better training of scorers. Furthermore, because many scorers are also teachers, the discrepancy in scores may point to a lack of understanding or consensus of what scorers should look for as well as of what teachers teach in the classroom.

Experiments are another useful form of performance-based assessment. This method of assessment was used in a recent IAEP study which evaluated the mathematics and science skills of over 30,000 students in four countries and five Canadian provinces.[21] Students were tested on procedural tasks which they performed in front of an observer. In science, a majority of the questions asked students to draw on knowledge concerning the physical sciences and the nature of science; in math, students concentrated on measurement and geometry. The IAEP (NCES 1992e, p. 6) researchers discovered the following.

- Scores varied widely from task to task, suggesting that the measures tap a range of skills and knowledge.
- Scores on the various tasks varied significantly between countries/provinces in systematic ways, indicating real differences in performance between the various populations.
- The relative performances of countries and provinces were generally different from those identified by the written tests covering related curricular areas, suggesting that this method of assessment let students demonstrate their skills in ways that were not possible with traditional written tests.[22]

Trends Toward State Frameworks and Higher Standards for Student Performance

Some educators and policymakers believe that the skills and knowledge students should attain must be clearly defined and must emphasize high-level thinking. As a result, there has been a good deal of recent work to establish frameworks for curriculum and set high standards in all curriculum areas. Although there is a good deal of confusion over what frameworks and standards are, many support the view of O'Day and Smith (1992):

> "A common vision and set of curriculum frameworks establish the basis in systemic curriculum reform for aligning all parts of a state instructional system—core content, materials, teacher training, continuing professional development, and assessment—to support the goal of delivering a high-quality curriculum to all children" (p. 25).

In this view, ***performance standards*** describe what students should know and be able to do. ***Curriculum frameworks*** outline the content expected to be taught in core disciplines. Most importantly, all elements of the broadly defined education system are linked in a common effort to accomplish common goals.

Several groups have been involved in designing frameworks for science and mathematics (e.g., NCTM, the National Research Council, the National Science Teachers Association, the American Association for the Advancement of Science's Project 2061), but establishing frameworks and setting standards is largely a state initiative.[23]

According to the Council of Chief State School Officers (CCSSO), most of the change at the state policy level has reflected the NCTM standards in math. This process is still in its initial stages of implementation, with most States only piloting sample groups of schools or students. A safe estimation of activity is that approximately half of the States have developed or are moving toward curriculum frameworks in mathematics or science. However, exact determination is difficult because of a difference in judgment as to what constitutes a new curriculum framework. Lack of cohesive definitions among officials, policymakers, practitioners, and researchers point to one problem. Even the words "frameworks" and "standards" are used "idiosyncratically" (Pechman and Laguarda 1993).

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[21] The United States decided not to participate in the project until it could evaluate the results of this assessment.

[22] Another notable finding from the IAEP study provides insight into the different strategies students from different countries use to complete tasks. Student approaches ranged from guessing, to estimating, to calculating precise answers, depending on the strategies taught in the respective countries. For instance, Taiwanese and Scottish students tended to use precision over estimation, while those from Alberta and Saskatchewan showed a preference for estimation over precision.

[23] NCTM has been in the forefront of developing curriculum standards in math, and is frequently used as a strong resource and guideline for states interested in developing their own. Developed by professionals and education experts from 1986-88, the NCTM project subdivided grades into three categories, K-4, 5-8, and 9-12, and developed 13 specific statements about what each group should be able to do for each subdivision. Common themes throughout the standards include hands-on activities, access to quality instruction and equipment, cooperative work, problem-solving tasks, justification of thought process, and application of concepts to other areas outside of mathematics (NCTM 1989). The National Research Council of the National Academy of Sciences and the National Academy of Engineering expect to develop science education standards by fall 1994.

For instance, according to a 1992 CCSSO survey, 24 States currently have curriculum frameworks reflecting the NCTM standards, and 17 others are revising their frameworks to reflect the NCTM standards. Four States are developing frameworks to go with NCTM standards while six States have no such frameworks. The same study shows that 30 States have frameworks in science, while 15 are developing them. However, a 1992-93 study conducted informally by interviewing state officials by telephone determined a much lower level of state activity. This study found that only 15 States have established curriculum frameworks in math, and 9 have frameworks in science. An additional 15 States are developing curriculum frameworks in math, and 16 others are developing them in science (Pechman and Laguarda 1993). Such discrepancies point to the complex nature of the change itself. While changes at the policy level are evident, it is too early to determine how any national movement toward curriculum frameworks at the state and local level will affect teaching practices in the classroom and student learning.

If progress on the development of curriculum frameworks is slow, it is reasonable to assume that the more ambitious goals of systemic reform will be particularly challenging. Recent research suggests that policymakers are grappling with some of the complexities of reform. As Fuhrman and Massell (1992) report:

> "Systemic reform ideas seem to require unprecedented efforts to integrate separate policies, new strategies of policy sequencing, novel processes to involve the public and professionals in setting standards, challenges to traditional politics, complex efforts to balance state leadership with flexibility at the school site, extraordinary investment in professional development, and creative approaches to serving the varied needs of students. To compound the challenge, states are facing these extremely demanding issues at a time of severe fiscal difficulty" (p. 24).

Despite these difficulties, there are a number of promising new strategies and evidence of a growing commitment to continue the expansion and inclusion of American popular education. Given the complexity of the task, the Nation's commitment to raising the science and mathematics skills and knowledge of all Americans will surely be tested.

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Chapter 2
Higher Education in Science and Engineering

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HIGHLIGHTS

INTERNATIONAL COMPARISONS

- **Asian countries emphasize science and engineering in their education systems more than do European or North American countries.** In 1990, six Asian countries produced more than a half-million natural science and engineering (NS&E) bachelor degrees, slightly more than the number of NS&E degrees produced in Europe and North America combined. Also, Asia's ratio of NS&E degrees to total first university degrees is higher than in Europe or North America.

- **Compared to other countries, a high percentage of U.S. students receive a university education.** In 1991, 31 percent of the U.S. college-age cohort obtained a university degree, a proportion second only to Canada's.

U.S. HIGHER EDUCATION INSTITUTIONS

- **Enrollments in higher education doubled between 1967 and 1991.** In 1991, 14 million students were enrolled in 3,600 institutions. The largest rates of growth in student enrollments occurred in 2-year community, junior, and technical colleges and in "comprehensive" schools.

- **Degrees in higher education reached 1.9 million in 1991, of which 500,000 were in science and engineering.** As in past years, most S&E degrees were produced by research-intensive and comprehensive schools at the bachelors and masters levels, and by research-intensive and doctoral-granting universities at the doctorate level.

UNDERGRADUATE STUDENTS AND DEGREES

- **Undergraduate enrollments increased 3 percent a year between 1986 and 1991.** Part of this increase is due to higher participation rates by older students, women, and minorities. By 1991, 66 percent of the 12.4 million students enrolled in undergraduate institutions were women and minorities.

- **Freshmen interest in S&E majors is increasing.** The percentages of underrepresented minorities planning to study physics, biology, and engineering doubled in the last 20 years. National Merit Scholars, who showed declining interest in the NS&E in the late eighties, expressed increasing interest in these majors between 1989 and 1992.

- **Engineering enrollments have increased since 1990.** This increase is attributable to participation by women and minorities, whose total enrollment reached 116,000 in 1991—or 31 percent of all undergraduate engineering enrollment.

- **Degrees continued to decline in some S&E fields.** Between 1986 and 1991, the absolute number of degrees in engineering and mathematics/computer science fields showed a continual decline. In 1991, however, there was an upturn in natural science degrees due to increased participation rates for females.

- **Women and minorities obtained an increasing percentage of S&E degrees.** Women obtained 45 percent of all bachelors degrees in the natural sciences in 1991. Their participation rate in engineering degrees grew from 2 to 16 percent between 1975 and 1991. Underrepresented minorities (blacks, Hispanics, and Native Americans) modestly improved their participation rates in S&E degrees, from 9.5 percent in 1977 to 10.7 percent in 1991.

GRADUATE STUDENTS AND DEGREES

- **Graduate student S&E enrollments grew steadily at a rate of 2 percent per year from 1977-91.** Much of this growth was driven by large increases in the numbers of women and non-U.S. citizens entering these programs. By 1991, more than one-third of graduate S&E students were female and another quarter were foreign citizens.

- **Masters degrees in the natural sciences obtained by males declined by one-third between 1975 and 1991.** This decline, from 12,000 to 8,000 degrees, was somewhat offset by increasing numbers of degrees to females.

- **At the doctorate level, the number of engineering degrees grew at a faster rate than any other field.** Engineering degrees grew 6 percent annually since 1978, reaching over 5,000 degrees in 1991.

- **Foreign students continued to increase their percentage of U.S. doctoral degrees in S&E.** In 1991, foreign students obtained over 25 percent of all natural science degrees, over 40 percent of mathematics/computer science degrees, and over 45 percent of engineering degrees.

- **Asian countries depend on U.S. graduate schools to educate a significant proportion of their doctoral students.** Moreover, more than three times as many Asian S&E doctoral recipients planned to stay and work in the United States as S&E doctorate-holders from the Americas and Europe.

FINANCIAL SUPPORT

- **By 1991, research assistantships were 28 percent of the primary support for S&E graduate students.** Fueled by growing university research funding, research assistantships and teaching assistantships have, over the last 20 years, displaced fellowships and traineeships as the major graduate support mechanism.

Introduction

Chapter Background

Higher education in science and engineering (S&E) is an issue of growing importance both nationally and globally. To highlight key aspects of that issue, the indicators in this chapter have been grouped into the following topic areas.

- *Global education levels.* Access to higher education has implications for the skill levels and technological capabilities of a society, and it is useful to compare university degrees across countries in three world regions that currently dominate global economic growth: Asia, Europe, and North America. Comparisons are made of the participation rates of college-age cohorts in S&E degrees, and of differences in access to university education for males and females in selected countries.
- *Characteristics of U.S. institutions that grant degrees in S&E.* Universities and colleges are classified to show in which types of institutions students obtain the majority of S&E degrees at different degree levels. Data on undergraduate instruction in science fields are grouped by type of institution to show differences in aspects of S&E education, e.g., the proportion of teaching between full-time faculty and teaching assistants.
- *Characteristics of the U.S. student population at the undergraduate and graduate levels.* For several years, there has been national concern over the declining interest of American students in studying S&E at the higher education levels. However, recent data on freshman major choices, enrollments, and degrees indicate an increasing interest in S&E education. Initial indicators show a turnaround in interest in S&E on the part of all students, and successful degree completions in S&E by rising numbers of women and underrepresented minorities.
- *Foreign students in U.S. higher education.* The U.S. higher education system plays a significant role in training the S&E human resource base in other countries. U.S. academic institutions attract many highly qualified foreign students who persist in advanced study and research and obtain doctoral degrees in science and engineering. The number of foreign students in graduate S&E programs has grown so fast that they now account for almost half of the doctorates awarded in some S&E fields.

Chapter Organization

This chapter is organized into five major parts. The first begins with a broad picture of international education levels to provide a context for U.S. higher education in science and engineering. This discussion makes use of a new global database on human resources for science in order to compare bachelors level university degrees in the natural sciences, social sciences, and engineering. Degree data in these fields are available for 6 Asian countries, 22 European countries, and 3 North American countries.

The second part shifts to the United States, and provides a brief overview of higher education for all levels and fields of study. It addresses indicators related to the characteristics of U.S. academic institutions, including the different types of institutions that award S&E degrees at various levels. New data are included on the hours of instruction undergraduates receive from full-time faculty versus teaching assistants in selected science fields at different types of institutions.

The next part focuses on indicators of undergraduate S&E enrollment and degrees, providing more disaggregation in fields of science in U.S. higher education than was possible for the international education discussion. For the first time in the *Science & Engineering Indicators* series, the chapter includes data on associate degrees in S&E and in engineering technology; it also presents information on technical education in Japan and Germany.

The fourth part of the chapter describes the graduate S&E student population by sex and race/ethnicity as well as citizenship, and provides new data on the stay rates of foreign doctoral recipients by country of origin.

The final part of the chapter provides information on major sources of financial support. Although data on undergraduate students are limited, data on graduate students in science and engineering are more extensive, covering the primary source and mechanism of support in various S&E fields for U.S. citizens and foreign students.

International Comparisons

First University Degrees[1]

The following discussion compares access to higher education in general and to the study of science and engineering in particular within three regions—North America, Europe, and Asia. The North American region includes Canada, the United States, and Mexico. The European region includes 22 countries for which data were available. (See appendix table 2-1.) The Asian region includes only six countries—China, India, Japan, Singapore, South Korea, and Taiwan—but these six represent 77 percent of Asia's, and 44 percent of the world's, population.

Asia. The six Asian countries annually produce more than 0.5 million natural science and engineering (NS&E) first university degrees—slightly more than the number of NS&E degrees produced in Europe and North America combined.[2] (See text table 2-1.)

The percentage of the college-age cohort—i.e., of 22-year-olds—who obtain a higher education degree varies widely among Asian countries by level of economic development. For example, only about 1 percent of China's 127 million 22-year-olds receives a university degree; this is the lowest participation rate in university education of all the countries listed in figure 2-1. On the other hand, 22 percent of Japan's 9 million 22-year-olds receive a university degree—a participation rate somewhat approaching that of the United States (31 percent). For the Asia region as a whole, only about 4 percent of the college-age cohort receives a university degree, compared to 11 percent in Europe and 24 percent in North America.

Although only about 1 percent of the 220 million 22-year-olds in Asian countries receive NS&E degrees (compared to 3 percent in Europe and 4 percent in North America—see appendix table 2-1), the *ratio* of NS&E degrees to total first university degrees is higher in Asia than in the other two regions. Within NS&E, there are significant variations by country. In China, 37 percent of all first university degrees are in engineering, while India only awards 4 percent of these degrees in this field and 20 percent in the natural sciences. Japan awards 20 percent of its first university degrees in engineering, and 6 percent in the natural sciences. (See figure 2-2.)

Text table 2–1.
First university degrees in S&E, by region: 1990

Field	Asia	Europe	North America
All first university degrees	1,673,901	813,650	1,356,618
Natural sciences	252,767	124,000	128,483
Social sciences	95,071	104,205	201,210
Engineering	261,410	134,813	118,704

See appendix table 2–1 *Science & Engineering Indicators – 1993*

Europe. Like Asia, the Central European countries—until recently—had very high ratios of NS&E degrees to total first university degrees. When those economies were under Soviet influence, science and engineering in higher education was emphasized as a way to build the communist state. Before its collapse, the Soviet Union had the highest ratio in the world of 22-year-olds with NS&E degrees—9 percent.[3] As countries such as Poland and Hungary continue to evolve toward more open economies, their universities are providing more opportunities to study non-S&E fields: Consequently, their ratios of NS&E degrees to total first university degrees are declining.

Among Western European countries, Germany has the highest percentage of college-age population with NS&E degrees—5 percent if ***Fachhochschulen*** (4-year degrees) are included, and 3.5 percent if only 5-year university degrees are considered. Spain has the highest university participation rate in all of Europe—19 percent of its college-age cohort. Spain's University Reform Law in 1983 and subsequent curriculum reforms increased university graduates in science and engineering (***Education Newsletter*** 1992). Between 1975 and 1990, NS&E degrees in Spain increased from 1 to 3 percent of the college-age cohort.

North America. In the North American region, Mexico has the highest ratio of NS&E degrees to total degrees: 25 percent of all first university degrees in Mexican universities are awarded in engineering. In contrast, only 6 percent of all first university degrees in Canada and 7 percent in the United States are in engineering. However, Mexico's university system is, like that of European countries, very elite. Just 8 percent of the college-age cohort obtains a university degree. Participation rates in university education are four times higher in Canada and the United States than in Mexico.

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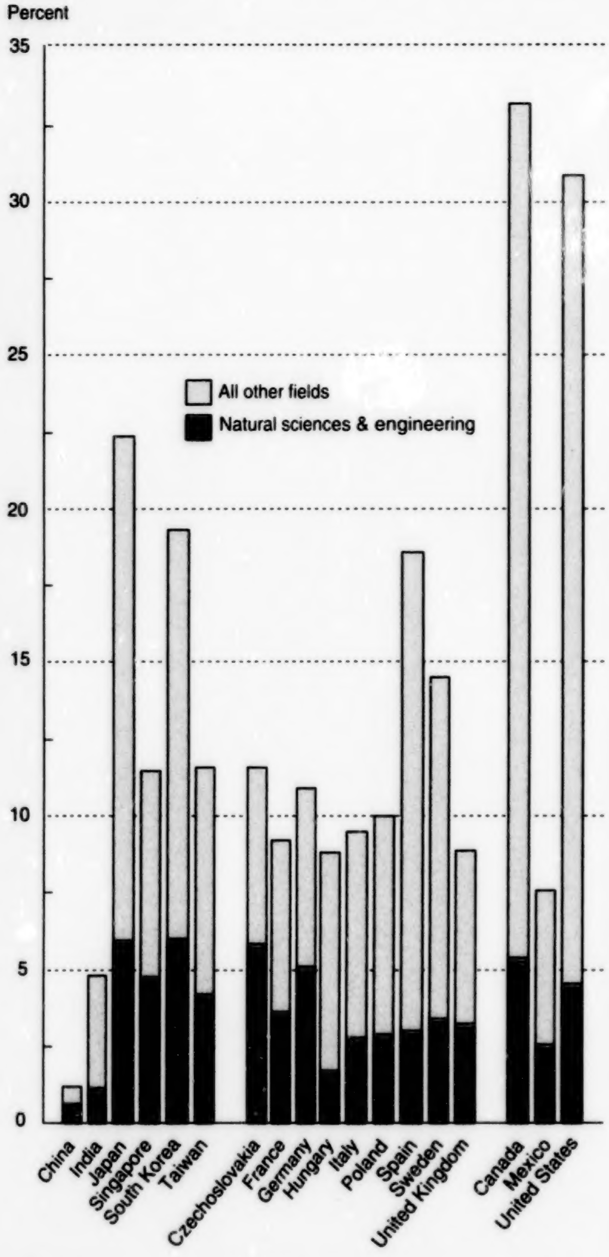
[1] Data in this section are primarily taken from Science Resources Studies Division, National Science Foundation, Global Database on Human Resources for Science and Engineering.

[2] Note that in these international comparisons, the natural sciences include the mathematical and computer sciences as well as the biological and agricultural, environmental, and physical sciences.

[3] Many of these were in engineering technology.

Figure 2-1.
Percentage of 22-year-olds with first university degrees in natural sciences and engineering, by country: 1990



NOTE: Belgium data are for 1988; data for Albania, Czechoslovakia, and Portugal are for 1989; and data for Austria, Finland, Greece, Sweden, the United Kingdom, and the United States are for 1991.

See appendix table 2-1. *Science & Engineering Indicators – 1993*

Participation Rates in NS&E Degrees by Sex

Access to NS&E degrees differs among countries and regions, but it varies still more by sex of students. (See text table 2-2.) In all countries for which NS&E degree data are available by sex of recipient, males receive the overwhelming majority of such awards. Japan has the highest proportion of male college-age students who obtain a first university degree in NS&E (11 percent), but the lowest proportion of females (fewer than 1 percent). Among the countries studied, South Korean females have the highest participation rate in NS&E degrees.[4] European women have a slightly higher participation rate in NS&E degrees than do women in other Asian countries and in the United States.

In terms of all first university degree awards, South Korean women have the highest participation rate (15

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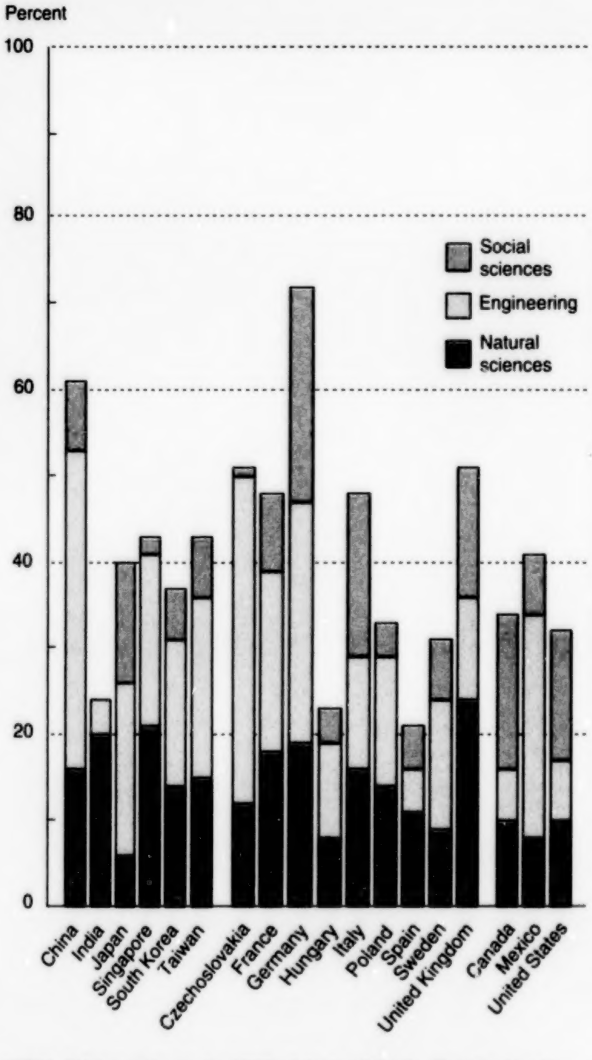
[4] This access to S&E degrees does not yet translate into a high proportion of females in the Korean S&E workforce, however (Jamison 1992).

Figure 2-2.
Science and engineering degrees as a proportion of all first university degrees, by country: 1990



NOTE: Belgium data are for 1988; data for Albania, Czechoslovakia, and Portugal are for 1989; and data for Austria, Finland, Greece, Sweden, the United Kingdom, and the United States are [illegible] 1991.

See appendix table 2-2. *Science & Engineering Indicators – 1993*

percent) of any Asian, European, or North American country except the United States (30.5 percent).[5] By current world standards, Japanese and Taiwanese women are also highly educated, and are more likely to receive a university education than females in France, Germany, or the United Kingdom. (See appendix table 2-3.)

Characteristics of Higher Education Institutions

There are 3,611 (1,566 public and 2,045 private) institutions of higher education in the United States (HEP 1993). In 1991, these institutions enrolled 14 million students and awarded almost 2 million degrees, a quarter of which were in S&E. (See figure 2-3.) The Carnegie Foundation for the Advancement of Teaching has classified those institutions into 10 categories based on the size of their baccalaureate and graduate degree programs, the amount of research funding they receive, and—for liberal arts schools—their selectivity of students.[6] First introduced in 1970, and periodically revised since, the classification scheme helps identify those schools that make the most significant contributions to S&E education in the United States. See "Classification of Academic Institutions" for a brief description of the Carnegie categories used in this chapter.

The number of students enrolled in U.S. institutions of higher education doubled between 1967 and 1991, rising from almost 7 million to 14 million. By type of institution, the largest rates of growth in student enrollments occurred in two categories: 2-year community, junior, and technical colleges; and comprehensive schools. Enrollment at these institutions grew at annual rates of 6 and 3 percent, respectively. (See figure 2-4.) In contrast, enrollment at liberal arts schools and research universities increased about 1 percent annually for the last 23 years. (See appendix table 2-4.)

Institutions With S&E Programs

Different categories of academic institutions predominate at each degree level. This section highlights the dominant Carnegie classes awarding associate, bachelors, masters, and doctoral degrees in science and engineering.

Text table 2–2.
First university degrees in NS&E, by sex and country

Country	Males	Females
	Percentage of college-age population	
France	5.2	1.9
Germany	8.5	1.5
Japan	10.8	0.9
Poland	3.9	1.9
South Korea	9.5	2.1
Sweden	4.8	1.9
Taiwan	6.7	1.5
United Kingdom	4.6	1.8
United States	7.4	1.4

See appendix table 2–3. *Science & Engineering Indicators – 1993*

Associate Degree Level. About 1,300 2-year institutions produce the overwhelming majority of associate degrees,[7] which represent a full quarter (484,800) of all degrees awarded in U.S. higher education. Only a small percentage of these degrees, however, are in science or engineering. In 1991, fewer than 4 percent of associate degrees (or 19,352) were awarded in S&E fields, and 9 percent (45,000) were awarded in engineering technology. These institutions thus account for only 1 percent of the 1.9 million S&E degrees in higher education. They do, however, account for 10 percent of the 64,586 engineering technology degrees in higher education. (See figure 2-3 and discussion on "Associate Degrees in S&E" later in this chapter.)

Bachelors Degree Level. There are 1,448 institutions that granted 356,000 degrees in S&E fields in 1991. (See text table 2-3.) Over 75 percent of all institutions with S&E baccalaureate programs are either comprehensive or liberal arts institutions. (See appendix tables 2-5 and 2-6.) However, the largest proportions of baccalaureates in S&E fields continue to be awarded by research and comprehensive schools. (See figure 2-5.) In 1991, they awarded 38 and 34 percent, respectively, of the year's S&E degrees. Liberal arts schools granted 10 percent of all S&E degrees that year. (See appendix table 2-5.)

Viewed in terms of S&E productivity, the relative significance of these three types of institutions changes somewhat. (See appendix table 2-5.) In 1991,

- S&E degrees accounted for almost 48 percent of the degrees awarded by liberal arts I schools. The degree awards were mainly in the social sciences.
- S&E degrees represented 44 percent of the degrees awarded by research I institutions; these were mainly in the natural sciences and engineering.

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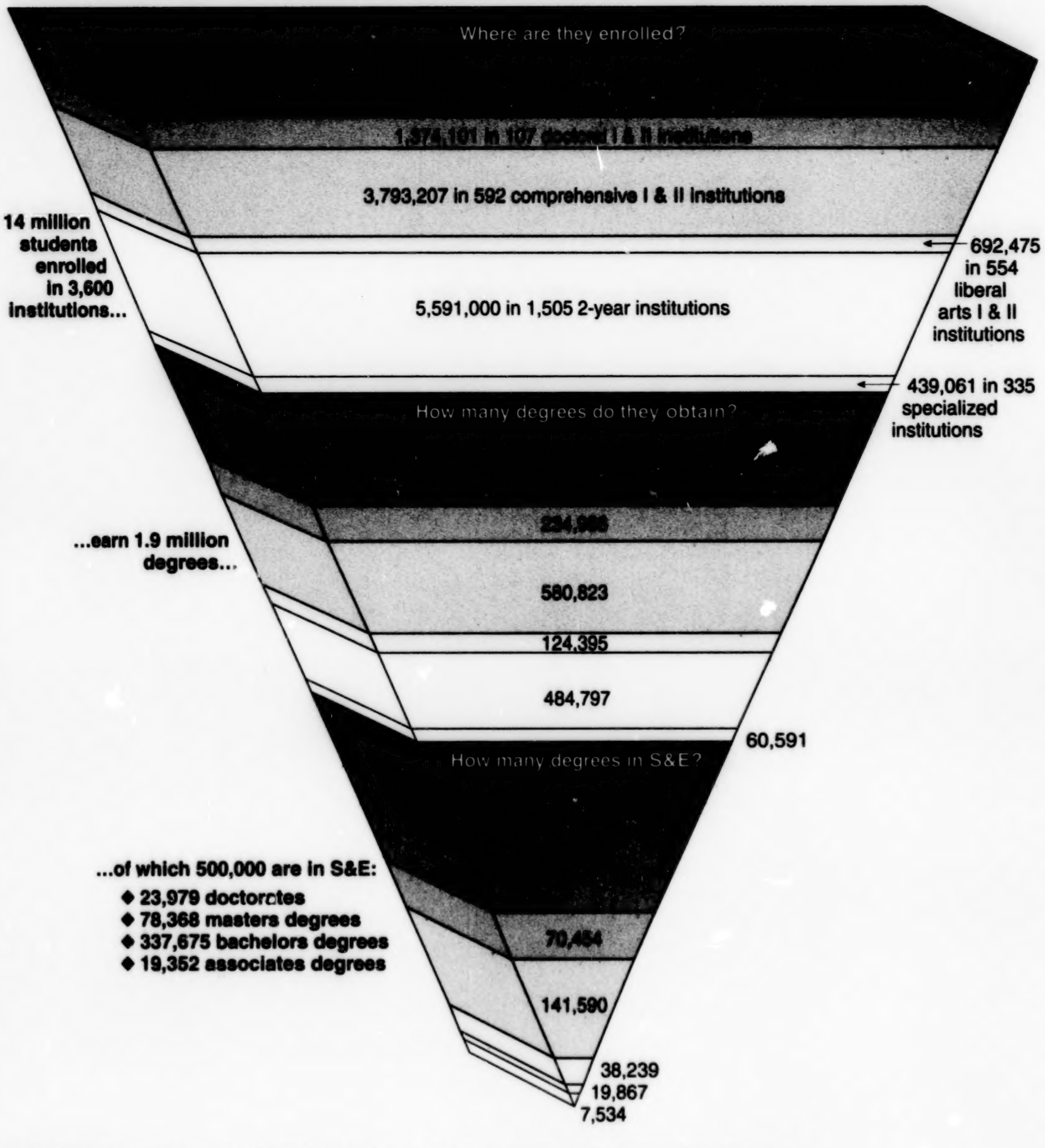
[5] The Japanese Imperial Government restricted higher education at the major universities in Korea during its 1905-45 occupation, but allowed missionaries to educate women, thereby contributing to the high level of female university graduates in Korea.

[6] The Carnegie classification is not an assessment guide, nor are the distinctions between classification sublevels (e.g., research I and research II) based on institutions' educational quality. Liberal arts I schools exercise more selectivity regarding students than do liberal arts II institutions, but in general the Carnegie categories are a typology, not a rank ordering.

[7] Associate degrees are granted for prebaccalaureate 2- to 3-year programs of study at the junior and community college level.

Figure 2-3.
U.S. higher education in 1991: Students, institutions, and degrees



NOTES: There were an additional 232,026 students enrolled in 71 "other" institutions. S&E = science and engineering.

See appendix tables 2-3, 2-4, 2-5, 2-6, and 2-17.

Science & Engineering Indicators – 1993

- S&E degrees accounted for over 24 percent of the degrees awarded by comprehensive I schools; these were split between the natural sciences/engineering and the social sciences.

Masters Degree Level. As at the bachelors level, comprehensive institutions make up the largest proportion of the 738 institutions with S&E programs at the masters level. (See figure 2-6.) However, S&E masters degree production is most highly concentrated in research universities: Almost 50 percent of the 79,500 S&E masters degrees in 1991 were awarded by this institution type. Comprehensive schools, on the other hand, produce only a quarter of all S&E masters degrees. (See text table 2-3.)

Classification of Academic Institutions

Following are brief descriptions of the Carnegie categories used in this chapter (Carnegie 1987).

Research I: These institutions offer a full range of baccalaureate programs, are committed to graduate education through the doctorate degree, and give high priority to research. They receive at least $33.5 million annually in federal support and award at least 50 Ph.D. degrees.

Research II: Same as research I, except that they receive between $12.5 and $33.5 million annually in federal support and award at least 50 Ph.D. degrees.

Doctorate-granting I: In addition to offering a full range of baccalaureate programs, the mission of these institutions includes a commitment to graduate education through the doctoral degree. They award 40 or more Ph.D. degrees annually in at least five academic disciplines.

Doctorate-granting II: Same as doctorate-granting I, except that they award 20 or more Ph.D. degrees annually in at least one discipline or 10 or more Ph.D. degrees in at least three disciplines.

Comprehensive I: These institutions offer baccalaureate programs and, with few exceptions, graduate education through the masters degree. More than half of their baccalaureate degrees are awarded in two or more occupational or professional disciplines such as engineering or business administration. All of the institutions in this group enroll at least 2,500 students.

Comprehensive II: Same as comprehensive I, except that they may also offer graduate education through the masters degree. All of the institutions in this group enroll between 1,500 and 2,500 students.

Liberal arts I: These highly selective institutions are primarily undergraduate colleges that award more than half of their baccalaureate degrees in arts and science fields.

Liberal arts II: These institutions are primarily undergraduate colleges that award more than half their degrees in liberal arts fields. This category includes a group of colleges that award fewer than half their degrees in liberal arts fields, but—with fewer than 1,500 students—are too small to be considered comprehensive.

Two-year community, junior, and technical colleges: These institutions offer certificate or degree programs through the associate degree level and, with few exceptions, offer no baccalaureate degrees.

Professional schools and other specialized institutions: These institutions offer degrees ranging from the bachelors to the doctorate. At least half of the degrees awarded by these institutions are in a single specialized field. These institutions include theological seminaries, bible colleges, and other institutions offering degrees in religion; medical schools and centers; other separate health profession schools; law schools; engineering and technology schools; business and management schools; schools of art, music, and design; teachers colleges, and corporate-sponsored institutions.

Text table 2–3.
S&E bachelors and masters degree awards, by institution type: 1991

Carnegie category[1]	Bachelors degrees		Masters degrees	
	Institutions	Degrees	Institutions	Degrees
Total	1,448	337,675	738	78,368
Research	101	132,108	101	38,573
Doctoral	102	49,371	105	14,679
Comprehensive	586	112,195	368	19,810
Liberal arts	527	36,231	72	1,624
Two-year	20	515	0	0
Specialized	94	4,866	69	2,182
Other	15	0	22	1,476

[1] Combines categories I and II.

See appendix tables 2–5 and 2–6.

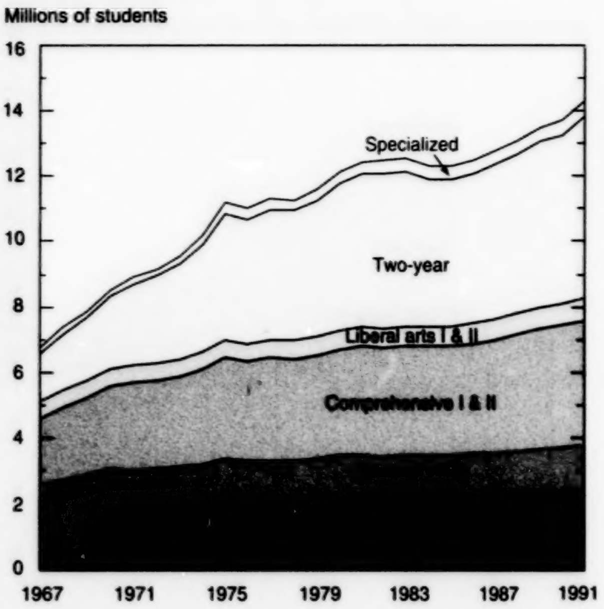
Science & Engineering Indicators – 1993

Doctoral Degree Level. At the doctoral level, degree production is highly concentrated: 150 research I, research II, and doctorate-granting I universities produce nearly 90 percent of all S&E doctorates, and receive 90 percent of all academic R&D funding (President's Council of Advisors on Science and Technology 1992). Collectively, these universities are three times the size they were 30 years ago in terms of enrollment and degree production and number of faculty and research staff. Due to research budget constraints, however, these research-intensive institutions are not expected to grow as they did in the 1960s and again in the 1980s. It has thus been postulated that only a very small fraction of current and future doctoral recipients in science and engineering can aspire to careers in academic research and teaching in research universities (Goodstein 1993).

Undergraduate Instruction by Type of Faculty

National concern over the quality of undergraduate education in science, mathematics, and engineering, and

Figure 2-4.
U.S. enrollment in higher education



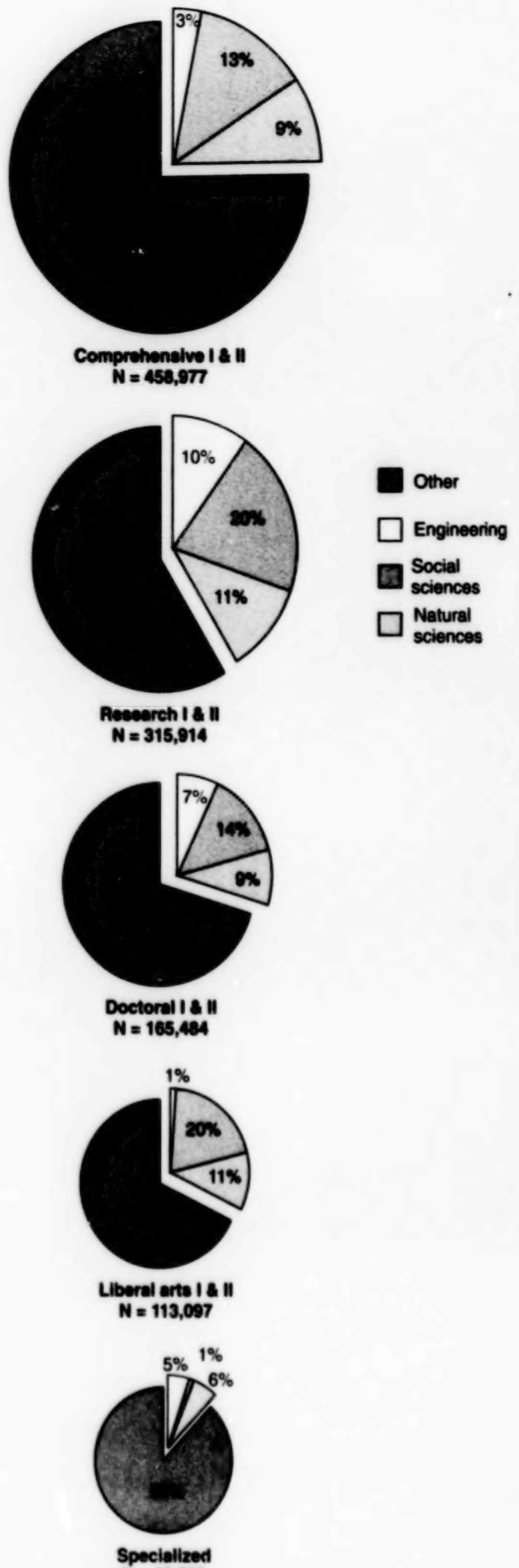
See appendix table 2-4. *Science & Engineering Indicators – 1993*

the relative priorities assigned to research and teaching, has been widely noted and discussed.[8] The specific issue is whether professors have advanced their field of specialization through research while entrusting their teaching duties to other faculty. Initial data that can shed some light on this issue are currently available for three fields—physics, geology, and sociology.[9] Full-time faculty in these disciplines account for 79 percent or more of the instructional contact hours with undergraduates; teaching assistants have 12 percent or less of instructional contact hours. The balance of instruction was provided by part-time and adjunct faculty. Text table 2-4 shows the percentage of instruction by full-time faculty in these fields across all institutions.

When instructional hours are examined by institution type, it can be seen that undergraduates at research-intensive universities (research I and II) receive a much larger percentage of their instruction from teaching assistants. (See figure 2-7.)

Teaching assistantships (TAs) account for about 21 percent of the primary support of S&E graduate students

Figure 2-5.
Bachelors degrees awarded, by institution type: 1991



NOTE: The natural sciences include math/computer sciences.

See appendix table 2-5. *Science & Engineering Indicators – 1993*

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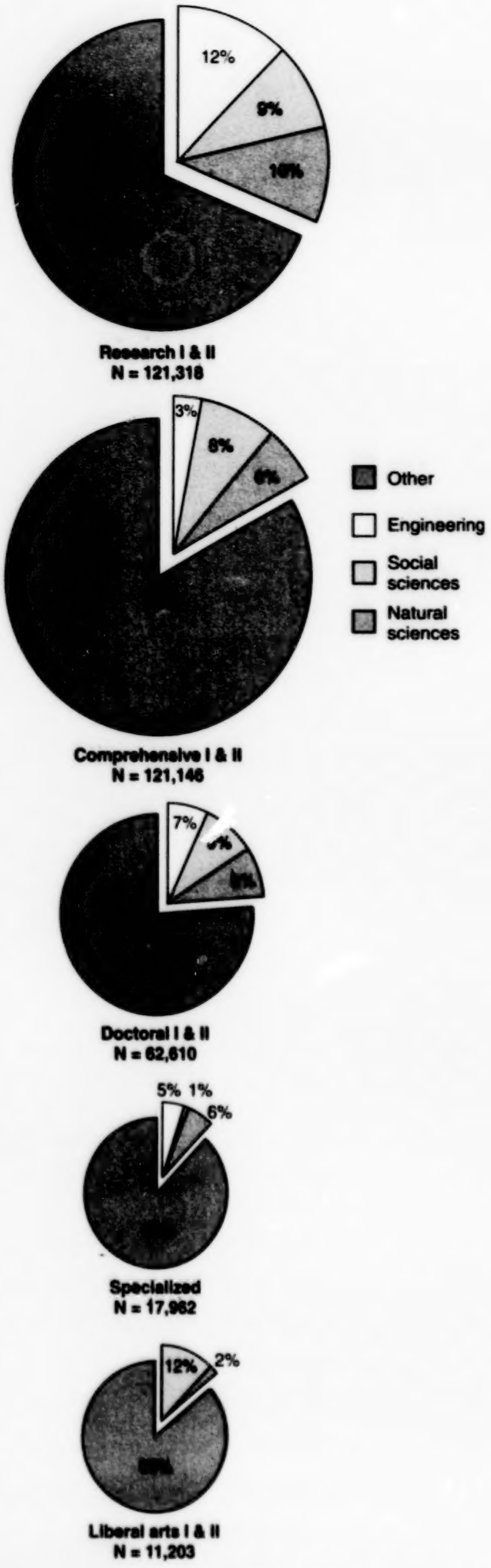
[8] See for example, Sigma Xi (1989) and Brown (1992).

[9] A comprehensive national survey of university faculty will be completed by 1995 to provide data on faculty characteristics and time spent in research and teaching by specific field. Currently available data are from the National Science Foundation's Higher Education Surveys, which gather national information on undergraduate curricula from 2- and 4-year colleges and universities. The three fields for which surveys have been completed as of this writing are geology, physics, and sociology (SRS 1992d, 1992e, and 1992f). Departments in these fields specified the hours of undergraduate instruction provided by professors and teaching assistants for lectures, laboratory work, and discussion groups.

Figure 2-6.
Masters degrees awarded, by institution type: 1991



NOTE: The natural sciences include math/computer sciences.

See appendix table 2-5. *Science & Engineering Indicators – 1993*

(SRS 1993a). (See appendix table 2-32.) In 1991, about 65,000 graduate students—mostly concentrated in research universities and doctoral-granting institutions—received such assistantships.[10] Teaching assistants provide over 36 percent of undergraduate instructional contact hours in physics at research universities, but only 3 percent at comprehensive universities or liberal arts colleges.

Undergraduate S&E Students and Degrees

This section provides data on enrollments of undergraduates and their plans to major in science and engineering. It also presents data on actual associate and bachelors degrees awarded. Trends are provided by sex and race/ethnicity.

Recent Trends in College Enrollments

The pool of college-age students (20- to 24-year-olds) has been decreasing by about 2 percent annually since 1980. Nonetheless, undergraduate enrollments ***increased*** during the 1980s—almost 3 percent during the latter half of the decade. Moreover, between 1990 and 1991, enrollments increased 4 percent, when an additional 500,000 students raised undergraduate enrollments to 12.4 million. (See appendix table 2-8.)

In the face of a declining college-age population, part of this increased enrollment is due to greater participation in undergraduate education by older students, women, and minorities. By 1991, 66 percent of all students enrolled in undergraduate institutions were women and minorities. These groups represented only 57 percent of undergraduate enrollment in 1976. Asians and Hispanics—especially females in these groups—accounted for the highest rates of increase in minority enrollments, with annual increases of 9 and 7 percent, respectively, between 1976 and 1991.

Engineering Enrollments[11]

Because engineering programs frequently begin in the freshman year, students tend to declare an engineering or engineering technology[12] major early in their college career. Data on these enrollments provide early indicators of future degree production.

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[10] An estimated 26,000 of these teaching assistants are foreign graduate students; see "Support for S&E Graduate Students."

[11] Data in this section are from the Engineering Manpower Commission. The commission collects trend data on full- and part-time engineering and engineering technology enrollments in both baccalaureate and 2-year programs as well as on enrollments of women and minorities.

[12] Engineering technology curricula have traditionally emphasized hands-on experience with advanced technologies, rather than a theoretical engineering curricula in mathematics and science. The Accreditation Board of Engineering and Technology defines engineering technology as that part of the field requiring the ***application*** of knowledge and methods of science and engineering, combined with technical skills.

Text table 2–4.
Percentage of undergraduate instruction provided by faculty: 1990

	Physics	Geology	Sociology
	Percent		
Full-time faculty	85	79	82
Part-time faculty	7	9	15
Teaching assistants	8	12	3

See appendix table 2–7 *Science & Engineering Indicators – 1993*

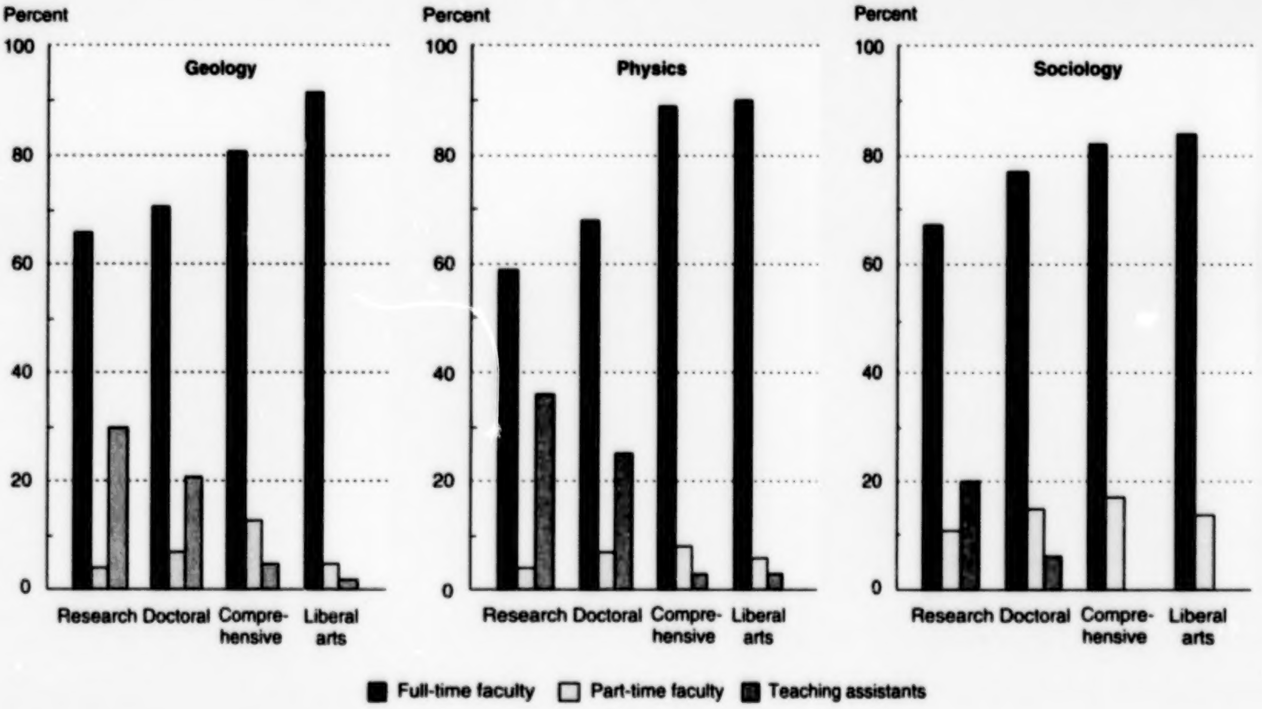
Full-time enrollments in engineering programs increased from the late seventies until the early eighties, and then declined slightly each year until 1989. This decline in engineering enrollments was partly based on demographics. After 1982, the U.S. pool of college-age students started decreasing slightly by about 100,000 per year; this decline became steeper after 1986 (500,000 a year). In 1990 and 1991, engineering enrollments increased slightly after a 9-year decline, although the pool of college-age students has not stopped decreasing in size.

In 1992, engineering enrollments increased substantially, as 4,700 more students enrolled in full-time undergraduate engineering programs than in the previous year, bringing total enrollment to 344,126 students. (See appendix table 2-9.) The increase was due to greater participation by women and minorities, whose enrollments reached 116,000 in 1992.[13] (See figure 2-8.) Participation by these groups has been growing concurrent with declining enrollments in engineering by white males. (See appendix table 2-10.) Between 1979 and 1992, as a proportion of all undergraduate engineering enrollments,

- enrollment of blacks grew from 4 to 7 percent,
- enrollment of Hispanics grew from 3 to 6 percent,
- female enrollment rose from 12 to 17 percent, and
- male enrollment declined from 88 to 82 percent.

Engineering technology enrollments declined from a high of 191,000 in 1981 to 128,500 in 1987; they have fluctuated slightly each year since, remaining at about the 1987 level. Unlike enrollments in engineering, however, engineering technology enrollments have not increased in the nineties. (See appendix table 2-9.)

Figure 2-7.
Proportion of undergraduate instruction provided by various faculty members, by field and institution type: 1990



NOTE: Data combine Carnegie categories I & II.
See appendix table 2-7.

Science & Engineering Indicators – 1993

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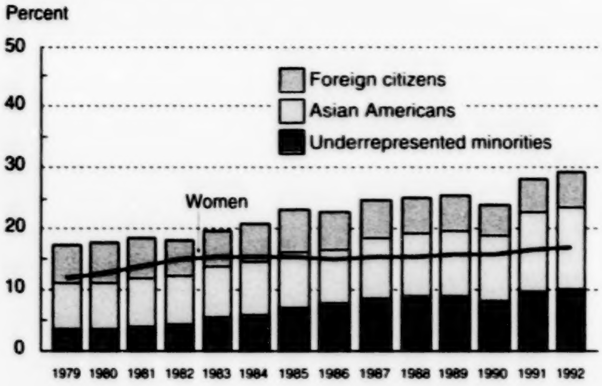
[13] Note, however, that even though women and minorities are an important portion of new enrollments, they still represent only a small percentage of total engineering enrollment.

Figure 2-8.
Representation of women and minorities in undergraduate engineering enrollments



NOTE: Underrepresented minorities are blacks, Hispanics, and Native Americans.

See appendix table 2-10. *Science & Engineering Indicators – 1993*

Characteristics of American College Freshmen[14]

The data presented in this section provide an indication of the growing interest of freshmen in studying S&E fields, as well as their perceptions of their academic preparedness for such majors. Specifically, this section explores trends in the following selected characteristics of first-time, full-time freshmen enrolled in 4-year universities and colleges:

- planned majors by sex and race/ethnicity,
- planned majors of National Merit Scholars, and
- students' self-reported need for remedial work in math and science.

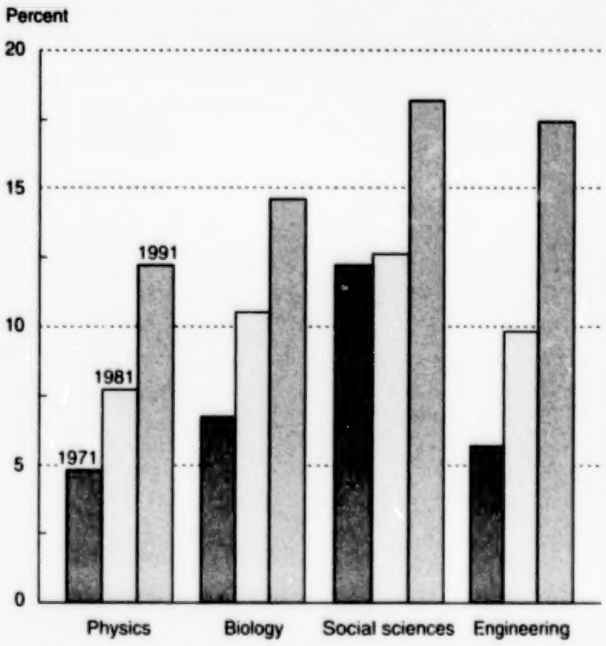
Planned Majors by Sex and Race/Ethnicity. For the last 20 years, about 30 percent of all freshmen in 4-year colleges and universities have said that they intend to major in science and engineering. Additionally, freshmen of every race/ethnicity have high aspirations for majoring in science and engineering: In 1992, about 44 percent of Asian, 35 percent of black and Hispanic, and 30 percent of white and Native American freshmen intended to major in science and engineering. (See appendix table 2-11.)

Choice of major within S&E fields differs by sex and race/ethnicity. Data on freshmen intentions for the last 20 years show that, regardless of race/ethnicity, all females—except Asians—intend a major in the social sciences more than in any other science field;[15] males of all races intend to study engineering above all other S&E fields. Minority females intend to major in the natural sciences and engineering more than do white females. Between 1971 and 1991, underrepresented minorities[16] have shown an increasing interest in S&E majors. (See figure 2-9.)

Despite high levels of freshmen intentions for an S&E major, in actuality, the percentage of students majoring in natural science, mathematics, and engineering fields declines from 27 to 17 percent between freshman and senior years (Astin, Astin, and Dey 1992).[17] Women and minorities experience even higher rates of attrition.

Planned Majors of National Merit Scholars. Are the best and brightest students interested in pursuing

Figure 2-9.
Minority representation among freshmen planning to major in a science or engineering field



NOTE: Data reflect underrepresented minorities only—i.e., blacks, Hispanics, and Native Americans.

See appendix table 2-12. *Science & Engineering Indicators – 1993*

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[14] Data on planned majors by sex, race/ethnicity, and need for remedial work are from the Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, unpublished tabulations. Although the institutional population for this survey is drawn from all eligible institutions of higher education (i.e., all institutions that were operating at the time of the survey and had a freshmen class of at least 25 students) listed in the annual U.S. Department of Education *Education Directory*, the actual sample is self-selected. For example, of the 2,725 eligible institutions invited to participate in the 1989 survey, 599 responded. Some of the bias that may result from this selection process is reduced in the stratification scheme.

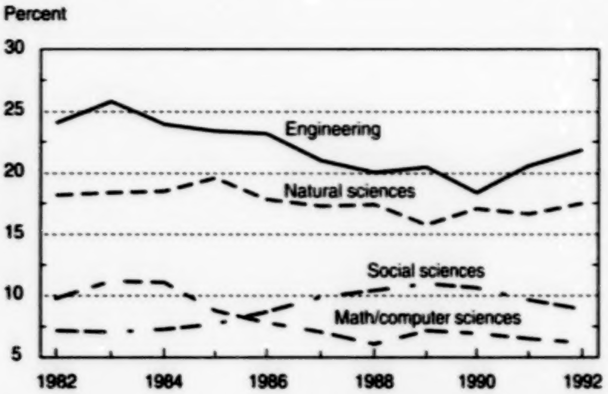
[15] Asian females intend to study the natural sciences more than any other S&E field.

[16] Underrepresented minorities in S&E include blacks, Hispanics, and Native Americans.

[17] Compare the freshman intentions data in appendix table 2-11 with the earned degree data in appendix tables 2-19, 2-20, and 2-21.

S&E fields? One indicator for determining the answer to this question is the stated choice of major of National Merit Scholars. These students represent the top 0.5 percent of the Nation's high school graduates in terms of academic achievement. In 1992, over 40 percent of all National Merit Scholars were interested in majoring in either the natural sciences or engineering. (See appendix table 2-13.) Interest in the biological sciences, physics, and mathematics and statistics increased, while plans to major in the social sciences and business decreased. Between 1985 and 1989, National Merit Scholars showed a declining interest in all S&E fields except the social sciences. From 1989 to 1992, however, this trend was somewhat reversed, as Merit Scholars expressed an increasing interest in majors in the natural sciences and engineering. (See figure 2-10.)

Figure 2-10.
Choice of majors of Merit Scholars



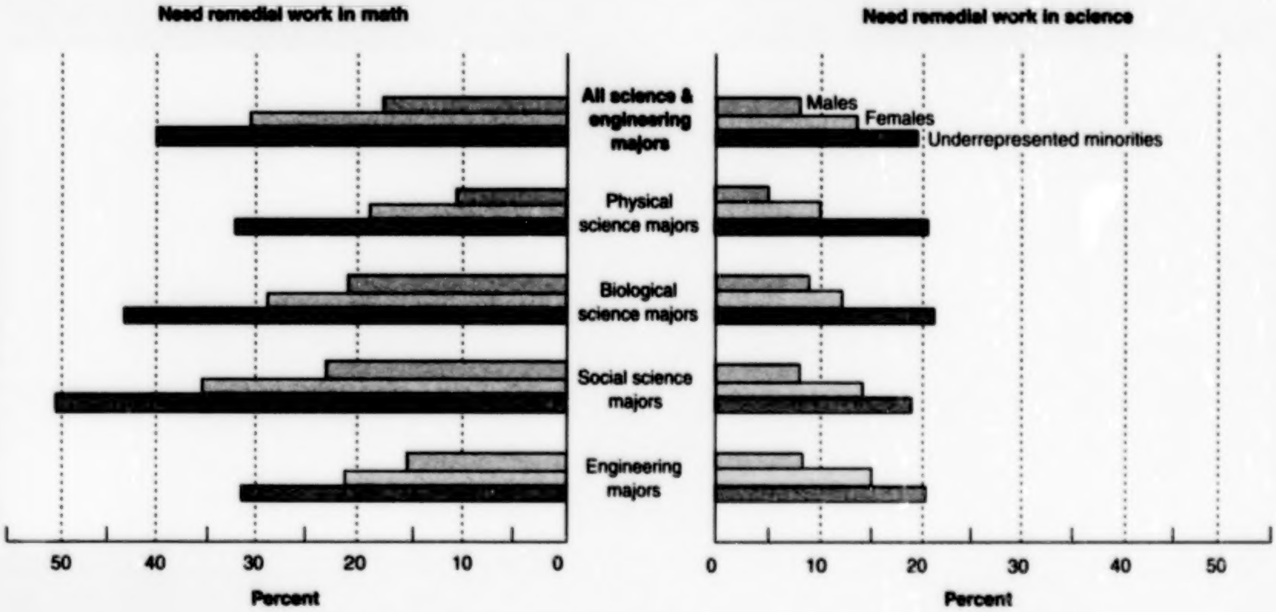
See appendix table 2-13. *Science & Engineering Indicators – 1993*

Reported Need for Remedial Work in Math and Science. A large proportion of freshmen say they need remedial work in math and science. For the last 15 years, about 20 percent of the freshmen class who intend to major in science and engineering thought they needed remedial work in math; about 10 percent felt they needed remedial work in science. (See appendix table 2-14.)

The perceived need for remedial work varies by intended major, sex, and race/ethnicity. (See figure 2-11.) In 1992, students planning to major in engineering or the physical sciences were less likely to express a need for remedial work in math or science than were their peers who planned a biological or social science major. Females intending to study physics expressed more need for remedial work in mathematics and science than did males. Between 30 and 50 percent of minority students across all fields said they needed remedial work in math, and between 20 and 24 percent said they needed remedial work in science.

Part of this lack of confidence in their ability to do college work in math and science relates to students' lack of persistence in these courses throughout high school. A study of coursetaking behavior of high school students conducted between 1987 and 1993 shows that a significant proportion of high school seniors do not enroll in

Figure 2-11.
Freshmen reporting need for remedial work in math and science, by intended major: 1992



NOTE: Underrepresented minorities are blacks, Hispanics, and Native Americans.
See appendix table 2-14. *Science & Engineering Indicators – 1993*

Technical Education in Japan and Germany

Japan and Germany are often cited for their commitment to vocational training for skilled personnel—a commitment that probably contributes to their economic success, particularly in manufacturing industries. Following is information on the technical education programs of these countries within their higher education systems.

Japan has technical and junior colleges that provide, among others, engineering technology degrees comparable to U.S. associate degrees in this field. The number of Japanese degrees at this level are, however, relatively small, amounting to about one-fifth of Japan's university degrees in engineering (Monbusho 1991). In 1991, Japan produced around 18,000 degrees at the associate level and 87,000 engineering degrees at the bachelors level. Programs of study in engineering technology offered at Japanese junior colleges include information processing, laboratory technician training, and electronics (Cummings 1993). Graduates in Japanese technical colleges are trained in more narrowly specialized technical areas in engineering (production, construction, industrial chemistry, information, and electronics) than are junior college graduates. Over 90 percent of Japan's junior and technical college graduates directly enter the country's high-skill labor force.

German polytechnics, called ***Fachhochschulen***, prepare students for work in various technical specialties. There is no equivalent institution in the United States, but the bachelors degree in engineering technology in U.S. universities is similar to the ***Fachhochschulen*** engineering degree. With approximately one-third of the college-age population of the United States, Germany produced 20,000 ***Fachhochschulen*** graduates in 1990—slightly more than the 19,000 U.S. engineering technology degrees awarded at the bachelors level that year.

Fachhochschulen were established in the early 1970s as an educational reform to address the serious shortage of skilled workers (Friedeburg 1990). They are an important source of training for engineers, accounting for slightly more than the number of university engineering degrees awarded in Germany (Mintzes and Tash 1984). Germany would like to divert more of its engineering students from universities to ***Fachhochschulen*** and have an even greater percentage of graduates trained in these polytechnics. The German Government is establishing new ***Fachhochschulens*** in the former East Germany to create a more highly skilled labor force and to foster economic growth in that region.

any science or mathematics course.[18] Females, more often than males, are advised that they do not need to take math or science in their senior year. (See appendix table 2-15.) In the senior class of 1993, only 13 percent of the males and 9 percent of the females had taken calculus; only 32 percent of the males and 27 percent of the females had taken physics. (See appendix table 2-16.) Among all students planning a career in mathematics, science, or engineering, fewer than two-thirds had completed a physics course, and only a third had attempted a high school calculus course.

Associate Degrees in S&E

Technical education contributes to a skilled and competitive labor force. ("Technical Education in Japan and Germany" describes how other countries provide the vocational training critical to a highly industrialized economy.) For example, most of the 700 colleges offering associate degrees in engineering technology have arrangements with secondary schools to offer technical preparation programs, and with industry to train or retrain workers.[19] Additionally, the increased emphasis on a competitive workforce has caused community colleges to establish new advanced technological education programs. The National Science Foundation has a $10 million budget in 1994 to improve such programs in 2-year institutions. This section provides some baseline information on associate degrees in science, engineering, and engineering technology.[20]

In 1991, of the 486,000 associate degrees awarded, only 19,000 were in S&E fields and 45,000 were in engineering technology. (See appendix table 2-17.) Associate degrees in S&E have declined in absolute numbers from 1983 to 1991, reflecting the decrease in the pool of U.S. college-age students. In engineering technology, associate degree awards increased an average of 6 percent per year from 1975 to 1985; there has been a 2-percent annual decline since then, somewhat mirroring the decline in engineering bachelors degrees.

Women receive almost half of all associate degrees awarded in the natural sciences and mathematics/computer sciences, but only about 11 percent of the degrees in engineering and engineering technology. Associate degrees declined between 1983 and 1991 for males, but not for females or underrepresented minorities. (See text table 2-5 and appendix tables 2-17 and 2-18.) This group—which includes black, Hispanic, and Native American students—is approximately 18 percent of the undergraduate population, and received 15 percent of the associate

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[18] These data are from the Longitudinal Study of American Youth. Several other studies related to this issue are discussed in chapter 1, "Student Persistence in Science and Mathematics Courses."

[19] Almost all of these schools also have arrangements for student transfer to 4-year programs (SRS forthcoming).

[20] Overall trends are available for 1975 to 1991; degrees by race/ethnicity are available for 1983 to 1991.

Text table 2–5.
Share of associate degrees in S&E obtained by underrepresented minorities

Field	1985	1991
	—— Percent ——	
All fields	13.4	14.5
All S&E fields	12.2	15.1
Natural sciences	9.7	10.1
Math/computer sciences	12.2	19.6
Social sciences	26.2	25.7
Engineering	7.3	11.9
Engineering technology	10.7	13.3

See appendix table 2–18. *Science & Engineering Indicators – 1993*

degrees in S&E in 1991. This figure represents an improvement in participation rates in some fields of S&E from 1985 levels, mainly in mathematics/computer sciences and engineering. Junior colleges show a greater share of minority achievement (earned associate degrees) than 4-year colleges.

Bachelors Degrees in S&E[21]

Bachelors degree awards in science and engineering, like associate degrees, increased until the mid-1980s and then decreased for the rest of the decade. (See appendix table 2-19.) There were some variations by field, however. (See figure 2-12.)

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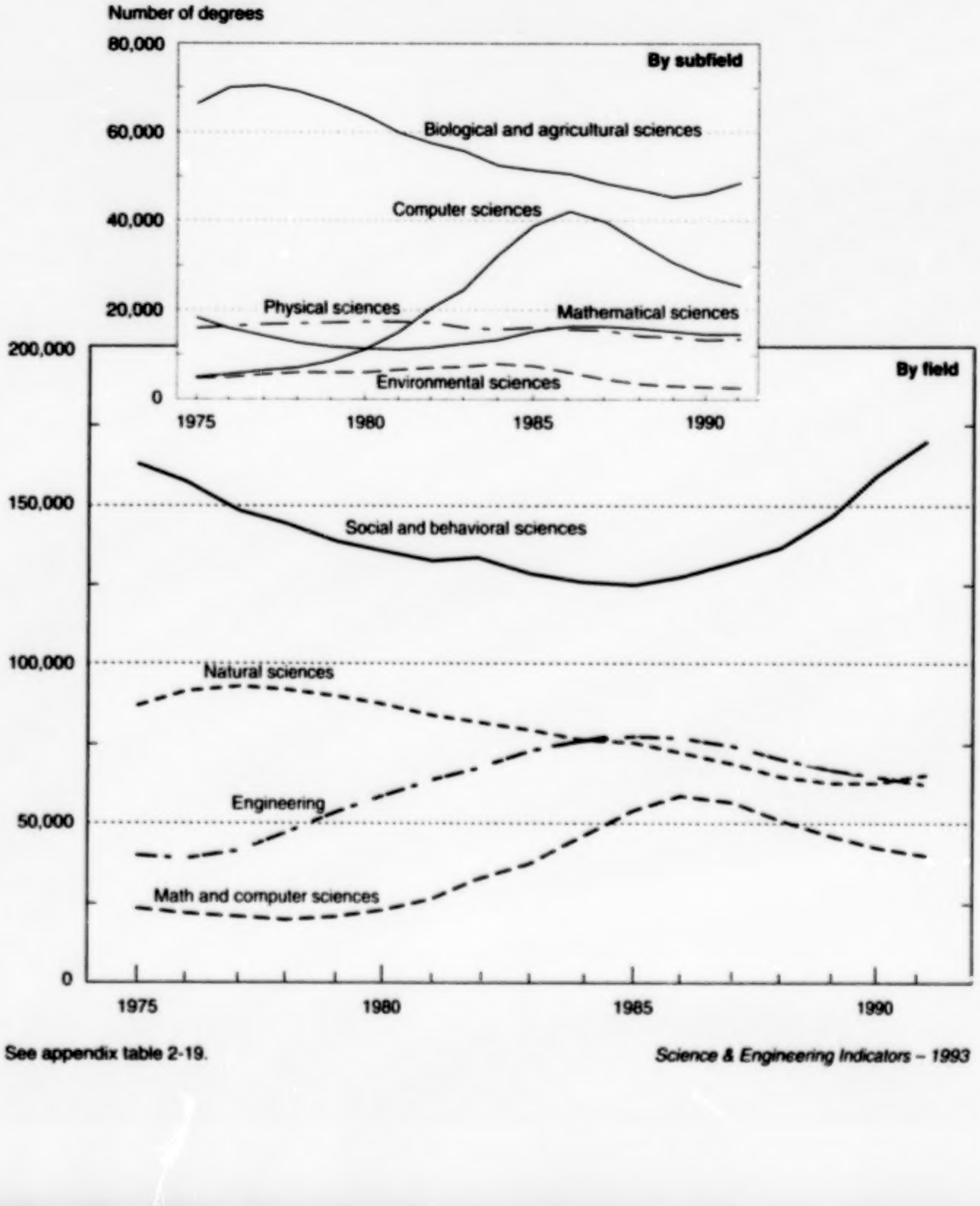
[21] Data in this section are from the National Center for Education Statistics, Earned Degrees and Completions Surveys.

Figure 2-12.
Bachelors degrees awarded in science and engineering



See appendix table 2-19. *Science & Engineering Indicators – 1993*

- The absolute numbers of *engineering* degrees declined 4 percent annually from 1986 to 1991; this decrease partially reflected the declining college-age population.
- *Natural science* degrees declined slowly, at 2.5 percent annually, over a long time period (1977-89). There was a slight upturn in degrees in this field in 1991—the result of increasing numbers of women obtaining degrees in natural science fields.
- The absolute numbers of *mathematics/computer sciences* degrees declined 7 percent annually from 1986 to 1991.
- Social science degrees declined 3 percent annually from 1975 to 1985, but have increased by more than 5 percent annually since 1985.

By subfield, there are still more variations in degree award patterns. (See figure 2-12.) The most dramatic of these variations is in the computer sciences, which dropped 10 percent annually between 1986 and 1991 after a long period of rapid growth. Awards in the biological and agricultural sciences declined slowly between 1978 to 1989, although there has been some growth in these subfields since then.

Bachelors Degrees by Sex. Women make up 55 percent of the undergraduate population and receive 56 percent of the bachelors degrees in the social sciences.[22] Women are approaching similar parity in a few fields of the natural sciences. For example, women received 49 percent of the bachelors degrees in the biological sciences in 1991. (See text table 2-6.) However, women received only 32 percent of the bachelors degrees in the physical sciences in 1991. Physics departments have only 5 percent female faculty and few minorities, perhaps adding to the difficulty of attracting these student populations (SRS 1992e). Males obtain the vast majority of engineering and engineering technology degrees, and the majority of mathematics/computer sciences degrees.

Overall, the increasing equality in the natural sciences has not resulted from large increases in the number of female degrees between 1975 and 1991; degrees to females during this period increased only 1 percent annually, from 23,000 to 29,000. Rather, there is a higher female participation rate because degrees awarded to females did not decline, as they did for men. Degrees awarded to men in the natural sciences began to decline in 1977, dropping 3 percent annually from 65,000 in 1977 to 36,000 in 1991. (See appendix table 2-19.)

Text table 2–6.
Distribution of bachelors degrees in S&E, by field and sex

Field	1975		1991	
	Male	Female	Male	Female
	Percent			
Natural sciences	73.4	26.6	55.5	44.5
Physical sciences	81.2	18.8	67.6	32.4
Environmental sciences	83.0	17.0	71.3	28.7
Biological/agricultural sciences	70.7	29.2	51.3	48.7
Math/computer sciences	62.9	37.0	63.9	36.1
Mathematics	58.0	42.0	52.7	47.2
Computer sciences	81.0	19.0	63.9	29.6
Social and behavioral sciences	57.0	43.0	44.0	56.0
Psychology	47.3	52.7	27.4	72.6
Social sciences	61.5	38.4	52.8	47.2
Engineering	97.9	2.1	84.5	15.5
Engineering technology	93.8	6.2	89.3	10.7

See appendix table 2–19. *Science & Engineering Indicators – 1993*

Bachelors Degrees by Race/Ethnicity. Recent freshmen intentions data indicate growing interest in planned S&E majors among all minority groups, but degree data show that minority groups remain underrepresented in terms of S&E baccalaureate awards.[23] Although 9 percent of the freshmen students who intended to major in S&E in 1986 were black, 4 years later only 6 percent of the bachelors degrees in S&E were obtained by this minority group. (See appendix tables 2-12 and 2-22.)

Blacks attained a 3.5-percent annual increase in engineering degrees and a 7-percent annual increase in mathematics/computer science degrees between 1977 and 1991. There has been no growth, however, in blacks' degree completions in the natural sciences. Hispanic students increased their engineering and computer science degrees at annual rates of 5 and 10 percent, respectively, between 1977 and 1991, and increased their natural science degrees at an annual rate of 2 percent. These increases in minority degrees[24] have resulted in modest improvements in their participation rates in NS&E degrees between 1977 and 1991. (See figure 2-13.)

Foreign students are only 3 percent of the undergraduate population, but they obtain 7 percent of the engineering degrees because of their strong focus on this field.

Graduate S&E Students and Degrees

Of the 415,000 graduate students in S&E fields in 1991,

- almost a third were in the social sciences,
- over a quarter were in the natural sciences,
- over a quarter were in engineering, and

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[22] Perhaps not coincidentally, the full-time faculty of U.S. sociology departments includes a high proportion (41 percent) of women (SRS 1992f).

[23] Studies and research on the participation of minorities in S&E education are discussed in "Improving Minority Participation in S&E Education."

[24] Degrees to Native Americans decreased in the same pattern as in the overall student population.

Improving Minority Participation in S&E Education

The slow progress in improving the retention and degree completion rates of minorities in science and engineering has been widely noted and discussed (see, for example, Bagayoka 1993). Increasingly, experts are realizing that precollege preparation plays a significant role in future S&E degree selection and completion. For example, to better understand the determinants of success in S&E, a longitudinal study of 25,000 undergraduate students was conducted between 1985 and 1989. The study found that overall academic competence and math achievement upon entering college were most closely linked with students' choice of and persistence in an S&E field (Astin, Astin, and Dey 1992). In other words, if a student has a strong high school preparation, other variables—like the type of academic institution attended, family income, parental occupation, etc.—are less significant in determining whether the student will obtain an S&E bachelors degree.

The impact of this and similar studies has led at least one group attempting to improve minority retention—the National Action Council for Minorities in Engineering—to shift its focus to precollege programs, including Saturday science academies, summer science camps and institutes, research apprenticeships, teacher enhancement, curriculum improvement, and problem-based learning. At the national level, math educators are developing standards for coursework and student accountability to improve academic preparedness at the high school level. At the federal level, the National Science Foundation and the Department of Education—with 80 percent of the funding for math and science education improvement—have signed a memorandum of understanding to coordinate their standards-based educational programs.

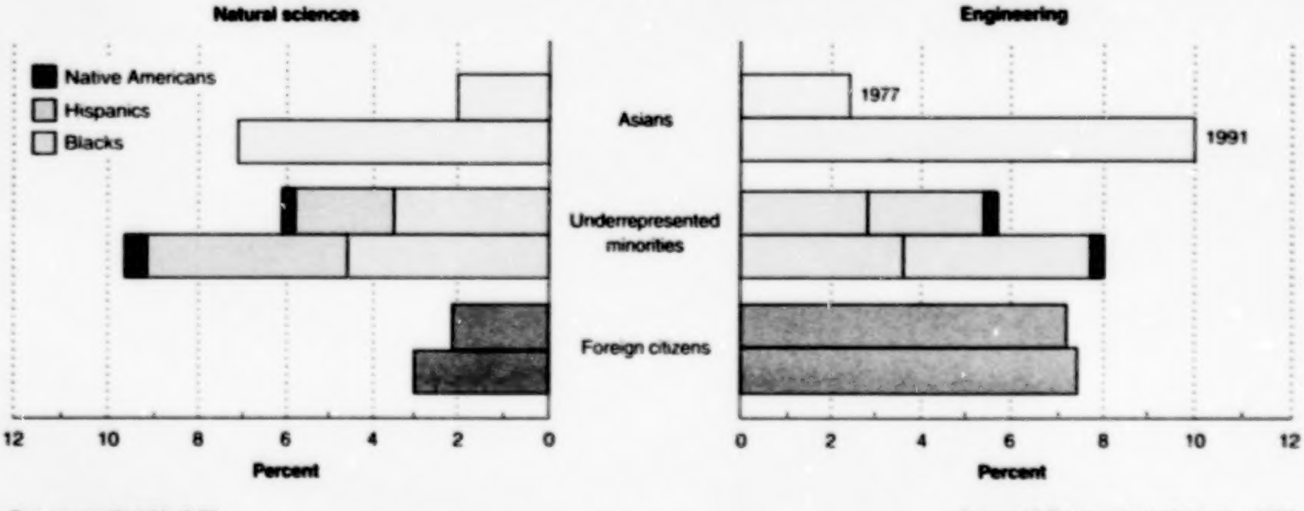
Higher education institutions are also establishing programs and improving introductory courses to reduce attrition in science and engineering. Curriculum reforms and innovative teaching methods (e.g., cooperative learning and visualization aids in higher mathematics) that began in a few selective research universities are now spreading to large state schools (Cipra 1993). Beyond providing better teaching and remedial tutoring, higher education institutions have also been asked to enhance financial support, social integration, student-faculty interactions, and essential mentoring of women and ethnic minorities to improve retention in science and engineering (Grant and Ward 1992).

- about an eighth were in mathematics and the computer sciences.

The S&E fields showing the greatest growth in both enrollment and degree awards were mathematics/computer sciences and engineering. Enrollments in these fields grew annually at 6 and 4 percent, respectively, between 1977 and 1991; enrollments in the natural and social sciences grew at less than 1 percent. (See appendix table 2-23.)

This section discusses the growth in graduate enrollments and degree awards, particularly among female and foreign students. It also examines growth trends in specific fields at the masters and doctoral levels.

Figure 2-13.
Bachelors degrees in the natural sciences and engineering awarded to minorities



See appendix table 2-22.

Science & Engineering Indicators – 1993

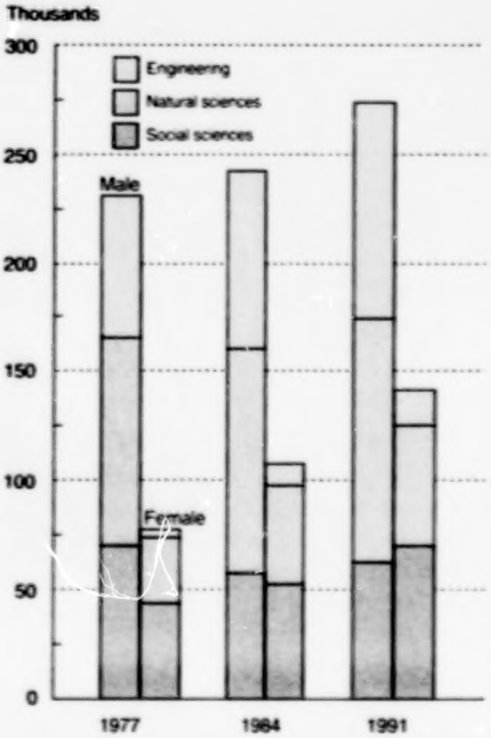
Recent Trends in Graduate Enrollments

Graduate student enrollment—both at the masters and doctoral levels—in S&E grew steadily at a rate of 2 percent per year from 1977 to 1991. As in undergraduate S&E education, much of this growth was fueled by large increases in the number of women enrolling in these programs. The number of women enrolled in S&E graduate programs rose from about 78,000 in 1977 to 142,000 in 1991. By 1991, more than a third of graduate S&E students were female, compared to a quarter in 1977. Representation of women varied by field, however, as shown in figure 2-14 and appendix table 2-23.

Foreign students also drove much of the growth in graduate enrollment. Enrollment by foreign citizens grew more than 5 percent annually between 1983 and 1991; non-U.S. citizens now comprise over one-quarter of all S&E graduate students.

Underrepresented minorities have had a slower enrollment growth rate than have all graduate students during this same time period, and from a smaller base.[25] In 1991, blacks, Hispanics, and Native Americans together accounted for only about 4.6 percent of the graduate student population in the natural sciences and about 4 percent in engineering. (See figure 2-15 and appendix table 2-24.)

Figure 2-14.
Graduate enrollment in science and engineering programs, by sex



NOTE: The natural sciences include math/computer sciences.

See appendix table 2-23. *Science & Engineering Indicators – 1993*

Masters Degrees in S&E[26]

From 1981 to 1991, the number of S&E masters degrees obtained each year increased at a slightly faster rate than did masters degrees in all fields (2 and 1 percent, respectively). This growth masked significant differences by field, however. For instance, annual production of masters degrees in mathematics/computer sciences and in engineering grew at much faster rates than did masters degrees in other S&E fields. Between 1981 and 1991, the number of degrees in mathematics/computer sciences increased an average of 6.7 percent annually, and nearly doubled over the period (from 6,800 to 13,000 degrees). Engineering degrees increased 4 percent annually during this period, reaching 24,000 degrees by 1991. Masters degrees in the natural sciences declined slightly from 1981 to 1991 at a rate of 1 percent annually; social science degrees increased by fewer than 1 percent annually.

The number of masters degrees awarded in the natural sciences began a slow decline in 1975, as male participation in this field dropped. The number of masters degrees in the natural sciences obtained by males declined by one-third between 1975 and 1991—dropping from 12,000 to 8,000. (See appendix table 2-25.) This decline was somewhat offset by an increasing number of natural science degrees for females: Masters degrees to females in this field increased from 3,000 to 5,000 during this period. Much of this growth was concentrated in the biological sciences.

In contrast to this increase for women, the participation rates of underrepresented minorities in masters level S&E programs has changed little since 1977—either across all of S&E or in terms of their relative fields of concentration.[27] (See text table 2-7.) Continuing the trends of the last 14 years, in 1991, underrepresented minorities received most of their masters degrees in the social sciences—4,600, compared to 600 degrees both in the natural sciences and mathematics/computer sciences, and 900 degrees in engineering. Masters degrees for Asians, on the other hand, were concentrated in engineering and in mathematics/computer sciences. Over the 1977-91 period, annual increases in awards to Asians in these fields were 7 and 14 percent, respectively.

Doctoral Degrees in S&E[28]

The number of S&E doctoral degrees grew twice as fast as all doctoral degree awards between 1978 and

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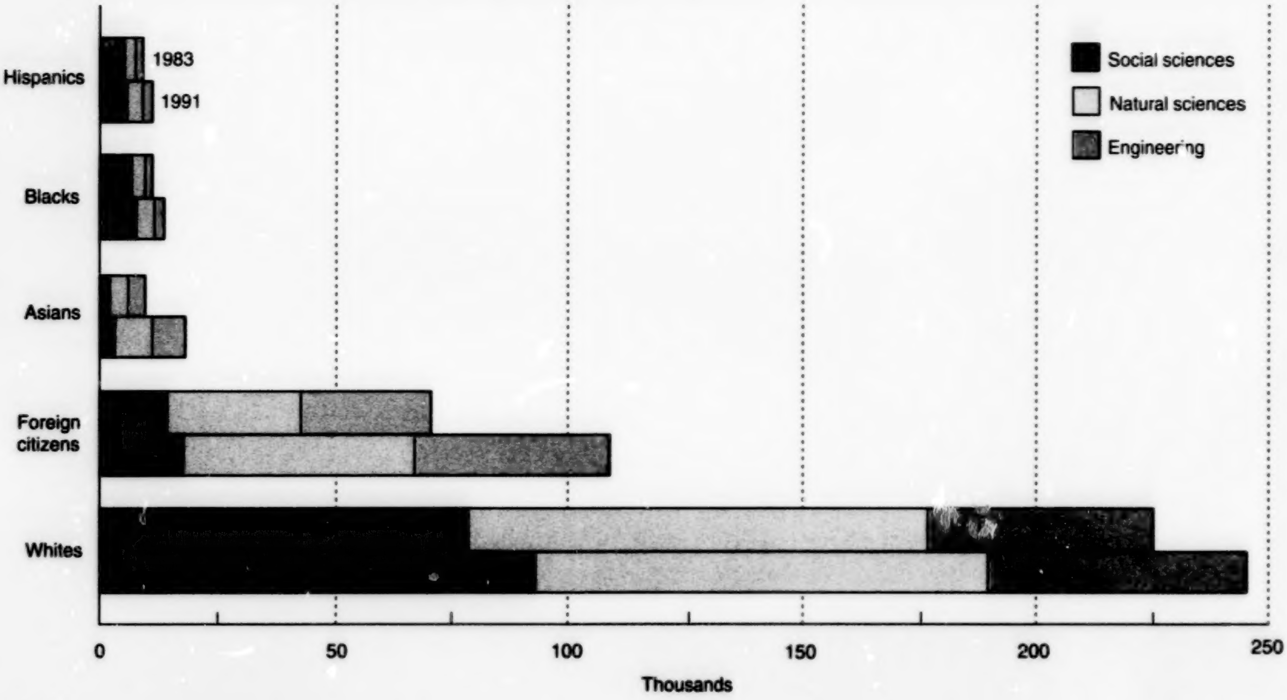
[25] Data on S&E graduate enrollment by racial/ethnic group are available for U.S. citizens only.

[26] Data for S&E masters degrees are from the National Center for Education Statistics annual survey of earned degrees; the data have been adapted to National Science Foundation field classifications.

[27] Data on race/ethnicity reflect U.S. citizens and permanent residents only.

[28] Data on S&E doctorates granted in the United States are from the National Science Foundation's Survey of Earned Doctorates; see SRS (1993d).

Figure 2-15.
Graduate enrollment in science and engineering programs, by race/ethnicity/citizenship



NOTE: The natural sciences include math/computer sciences.

See appendix table 2-24.

Science & Engineering Indicators – 1993

1991—2 percent versus 1 percent annually. The number of engineering doctoral degrees increased at a faster rate than did any other field, rising 6 percent annually since 1978 and reaching over 5,000 degrees in 1991. The number of mathematics/computer science doctorates obtained annually was around 1,000 between 1975 and 1985; this number increased to 1,800 degrees by 1991.

Text table 2–7.
Share of masters degrees in S&E obtained by underrepresented minorities

Field	1977	1991
	Percent	
All fields	9.1	7.9
All S&E fields	7.8	7.3
Natural sciences	4.0	4.5
Math/computer sciences	4.7	4.8
Social sciences	11.3	11.1
Engineering	3.2	3.8

See appendix table 2–26 *Science & Engineering Indicators – 1993*

Natural science awards have grown modestly, increasing from 8,000 to 10,000 between 1975 and 1991—a 1.4 percent average annual growth rate. The production of doctoral degrees in the social sciences has been quite stable since 1975 at about 6,500 awards annually. (See appendix table 2-27.)

Doctorates by Sex and Race/Ethnicity. Females received half the social and behavioral science degrees and over a quarter of the natural science degrees at the doctoral level in 1991. This represents a doubling of female participation rates in these S&E fields since 1975. However, women received relatively few engineering or mathematics/ computer sciences degrees at the doctoral level—9 and 17 percent, respectively. (See appendix table 2-27.)

The number of doctorates obtained by underrepresented minorities has increased in all fields of S&E, especially the social and natural sciences.[29] This growth is from a small base, however: These populations still represent only 0.4 percent of all S&E doctoral degrees. (See appendix table 2-28.)

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[29] Data on race/ethnicity reflect U.S. citizens and permanent residents only.

Foreign Students in U.S. Doctoral Programs

Doctoral Awards to Foreign Students by Field. Foreign students continued to increase their share of U.S. doctoral degrees in 1991. They obtained over 25 percent of all natural science degrees, over 40 percent of mathematics/computer sciences degrees, and over 45 percent of engineering degrees. (See figure 2-16.) These awards were primarily made to Asian natives: Students from Asian countries received 3 times more S&E doctorates from American universities than did students from North and South America and Central and Western Europe combined. (See "Asian Students in U.S. Universities.")

Foreign Student Stay Rates.[30] In the last few years, about half of the foreign students who obtained doctoral degrees from U.S. universities planned to stay in the United States following graduation. The decision to locate in the United States is influenced by employment opportunities to use their advanced knowledge, as well as the political and economic situation in the sending country. Plans to stay rates vary by country of origin. In 1991, about 50 percent of the foreign S&E doctoral recipients from North and South America planned to remain in the United States; about 56 percent of the European and 62 percent of the Asian S&E doctoral recipients planned to stay.[31] (See figure 2-18.)

By country, Canada has had a high percentage of doctoral recipients planning to remain in the United States. (See appendix table 2-29.) Among European nations, Greece and the United Kingdom have the highest percentages of S&E doctorates planning to locate in the United States—56 and 71 percent, respectively. Among the Asian countries that send significant numbers of doctoral students to U.S. universities, Taiwan and South Korea have the lowest stay rates after graduation; China and India have the highest. The pattern appears to be that as Asian economies develop, they have more capacity to absorb the large numbers of S&E doctorate-holders from U.S. universities. Because China is now the fastest growing economy in the world, the stay rate of U.S.-educated doctoral recipients from China may decline in the near future. (See appendix table 2-29.)

Across all countries, the percentages of those with *firm* plans to stay—i.e., those with firm appointments for postdoctoral study, or firm academic or industrial employment offers from organizations in the United States—are much lower than are the percentages of those who say they would like to stay. It is noteworthy,

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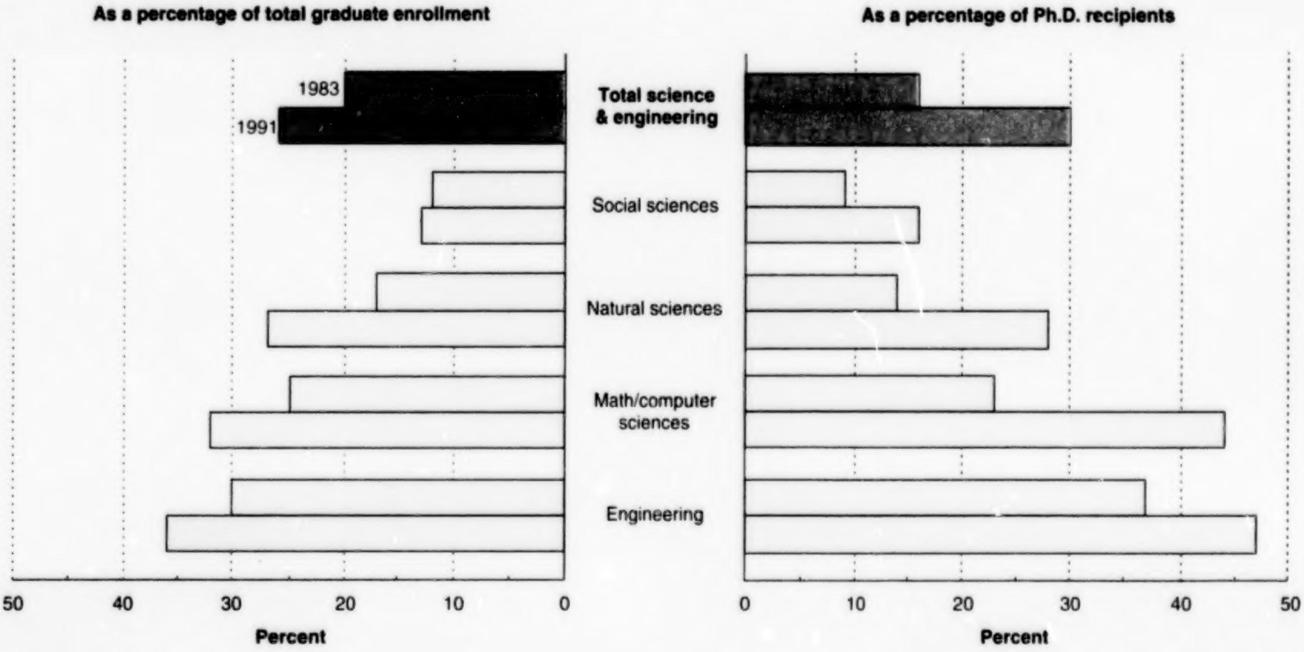
[30] Data in this section are derived from the National Science Foundation's Survey of Earned Doctorates. The survey item on postgraduation plans has an 80-percent response rate among foreign doctoral recipients.

[31] These percentages mask huge differences in numbers of doctorates. For example, in 1991, three times as many Asian S&E doctoral recipients planned to stay and work in the United States as did S&E doctorates from the Americas and Europe.

Figure 2-16.
Foreign citizens in U.S. graduate science and engineering programs



See appendix tables 2-24 and 2-28.

Science & Engineering Indicators – 1993

Asian Students in U.S. Universities

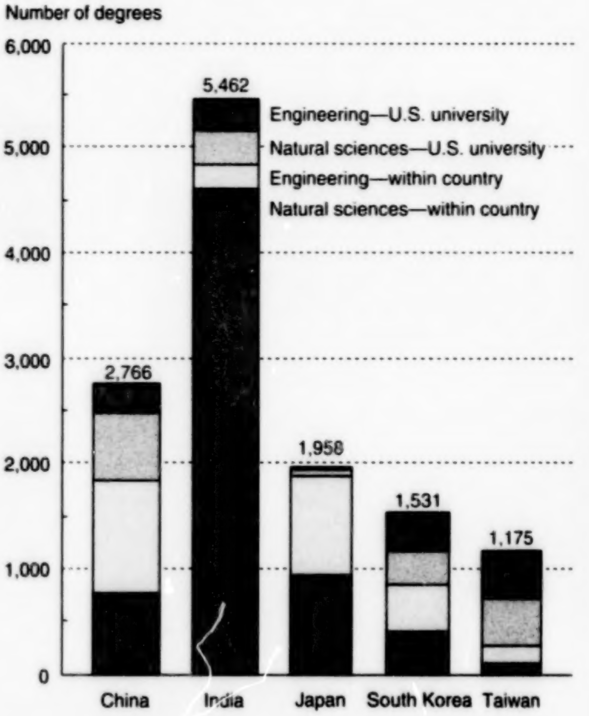
Over 400,000 foreign students—3 percent of total U.S. enrollment—attend U.S. institutions of higher education. Over half of these students (55 percent) come from Asia: In 1991, 43 percent of undergraduate foreign students were Asian, and 65 percent of the graduate (IIE 1991). One reason for this concentration is that the sharp jump in the value of Asian currencies relative to the U.S. dollar has greatly increased the number of Asian students with the financial ability to study in this country (SRS 1993c).

Asians tend to major in S&E. Over 80 percent of the baccalaureates obtained in the United States by Asian natives were in S&E in 1991 (SRS 1993c). Japanese students are the single exception to this trend. (See text table 2-8.) Over half of the Japanese students enrolled in undergraduate programs at U.S. universities in 1989/90 were in non-S&E fields.

At the graduate level, too, a large percentage of Asian students in U.S. universities are enrolled in S&E programs. For example, 96 percent of Taiwanese students and 93 percent of Indian students were in S&E fields in 1989/90. Asian countries have encouraged this focus on science and engineering by providing scholarships for study abroad in these fields.

U.S. higher education institutions are also a significant source for the doctoral education of Asian students, educating—based on data from China, India, Japan, South Korea, and Taiwan—approximately one-quarter of Asian Ph.D. recipients. U.S. universities provide more engineering doctorates to Indian students than does India, and more natural science and engineering doctorates to Taiwanese students than does Taiwan. About half of South Korea's doctoral degrees, and one-third of China's, are from U.S. universities. On the other hand, Japanese scientists and engineers obtain only a small fraction of their doctorates in the United States. (See figure 2-17.)

Figure 2-17.
Doctorates obtained in natural sciences and engineering by Asians within country and in the United States: 1990



SOURCE: Science Resources Studies Division, National Science Foundation, *Human Resources for Science and Technology: The Asian Region*, NSF 93-303 (Washington, DC: NSF, 1993).

Science & Engineering Indicators – 1993

Text table 2–8.
Asian students in U.S. universities

Country	Total enrollment in U.S. institutions		Study level		Major field of study	
	1989/90	1990/91	Undergraduate	Graduate	Natural sciences	Engineering
	Number		Percent			
China	33,390	39,600	12.9	82.7	44.0	20.1
Taiwan	30,960	33,530	19.0	76.3	51.0	45.0
Japan	29,840	36,610	61.7	19.5	31.0	14.0
India	26,240	28,860	21.1	75.5	40.9	52.5
South Korea	21,710	23,360	24.1	69.7	45.4	35.6

NOTES: Percentages by degree level and field are estimated from the Institute of International Education 1989/90 foreign student survey. Details do not add to 100 because of additional data not included here.

SOURCES: Institute of International Education (IIE), *Profiles 1989–90. Detailed Analyses of the Foreign Student Population* (New York: 1990); and IIE, *Open Doors, 1990–91: Report on International Education Exchange* (New York: 1991).

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however, that postdoctoral appointments are increasingly filled by foreigners who obtained their doctoral degrees from U.S. universities. (See appendix table 2-30.) In 1991, a full half of the postdoctoral appointments in S&E were offered to non-U.S. citizens who obtained S&E doctoral degrees in U.S. universities, up from about 39 percent in 1981.

Major Sources of Financial Support

The cost of higher education rose about four times faster than did family incomes between 1982 and 1992.[32] Not surprisingly, students have turned to other sources of support to help pay for their undergraduate and graduate education. In the last 10 years, external sources of student aid[33] for U.S. higher education have grown from $16 to $30 billion in constant dollars (Knapp 1992).

External sources of support have changed somewhat over the decade. The largest source of support was and continues to be the Federal Government. The lion's share of federal support consists of loans: Specifically, $13.7 billion (in 1992) in the Guaranteed Student Loan Program and about $9 billion in grants and other programs. (See appendix table 2-31.) In 1992, some 40 percent of the 14 million students enrolled in higher education at all levels relied on federal guaranteed loans to finance some part of their education. This proportion was up from 30 percent less than a decade ago (Knapp 1992).

Despite this increasing reliance on federal loans, however, the overall share of federal financial aid declined over the decade. In 1982, the Federal Government accounted for 80 percent of all student aid. By 1992, it accounted for 74 percent. Concurrently, academic institutions increased their share of total student financial support from 12 to 19.5 percent. State grants to students accounted for 6 percent of financial aid throughout the decade.

More detailed indicators of financial support for higher education are limited. This section presents data on support reported by (1) freshmen in 4-year colleges and universities and (2) S&E graduate students. Support sources and mechanisms are discussed, as are the support patterns for foreign students studying at U.S. institutions.

Support for College Freshmen[34]

The rising costs of higher education at 4-year colleges and universities have contributed to an increased student reliance on parents or other relatives for academic support. In 1992, about 63 percent of all freshmen, regardless of intended major, reported receiving at least $1,500 or more from parents or other relatives to finance their education. This proportion was up considerably from 1982, when only 46 percent reported receiving at least $1,500 from this source.[35]

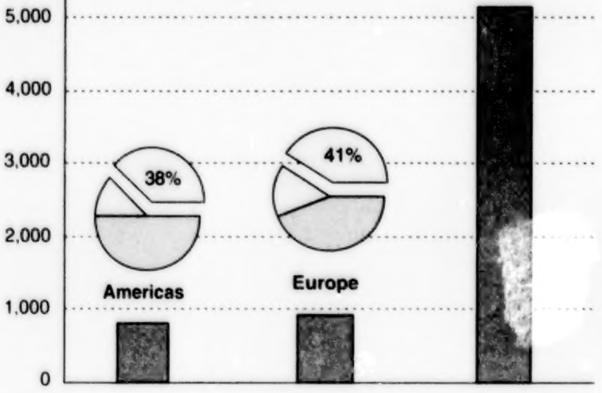
Two other sources of support became increasingly significant during this time period. In 1982, 9 percent of freshmen reported receiving at least $1,500 from their academic institutions in grants or scholarships. This proportion had climbed dramatically by 1992, when almost a quarter (22 percent) of all freshmen cited this source of support. Students' own savings accounted for at least $1,500 in support for 9 percent of the freshmen in 1982, and for 16 percent in 1992.

The proportion citing reliance on federal loans remained steady over the period, on the other hand. In 1992, as in 1982, about 18 percent of all freshmen reported receiving at least $1,500 from either federally guaranteed student loans or direct federal loans.

Support for S&E Graduate Students[36]

In 1992, academic institutions continued to account for the majority of support for masters and doctoral students in S&E. The predominant mechanisms of support for

Figure 2-18.
Number and status of foreign doctoral recipients: 1991



See appendix table 2-29. *Science & Engineering Indicators – 1993*

these S&E students were research assistantships (RAs) and teaching assistantships. These overall trends mask differences by degree level, field, and citizenship. The following paragraphs discuss these differences.

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[32] Costs at private and public universities increased around 4 percent annually during this period, while median family income grew about 1 percent annually (Knapp 1992).

[33] External sources include federal, state, and academic institutions' grant and loan programs.

[34] Data in this section are from the Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms, unpublished tabulations.

[35] The lower limit of $1,500 was reported in current dollars.

[36] Data on sources of graduate support are from the annual National Science Foundation fall survey of graduate S&E departments (SRS 1993a). The survey asks all full-time graduate students to indicate their "primary" source of support. Many students fund their graduate education with several different sources of financial aid, some of which are not reported on the survey. Consequently, although the data in this section represent a *majority* of support sources, they do not represent *all* sources.

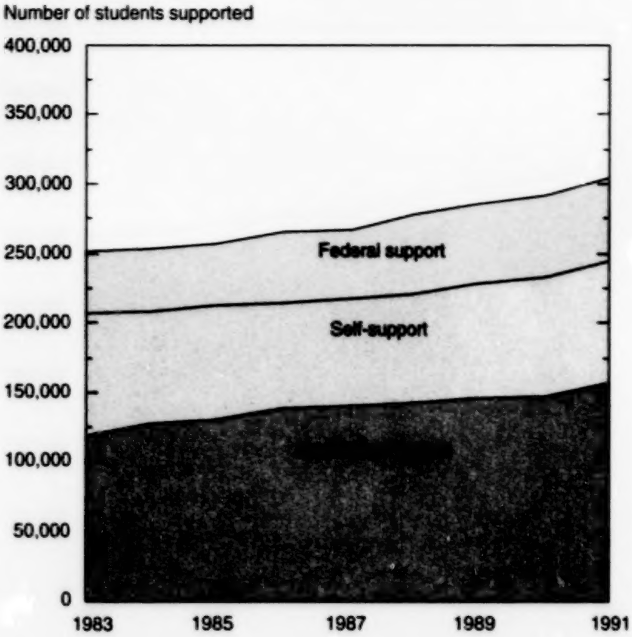
Support by Source. Since advanced education is a critical means of developing the human resources needed to perform the Nation's S&E activities, the academic, industrial, and federal sectors have traditionally been key sources of support for graduate S&E students. These students are thus far less likely than undergraduates to finance the largest part of their education through family or personal resources. In 1991, half of the primary support for graduate S&E students was provided by nonfederal sources (i.e., academic institutions[37] and private industry); 20 percent was from the Federal Government; and 30 percent consisted of self-support. Since 1983, the average annual increase in the number of students supported by these sources has risen by 3, 4, and 1 percent, respectively.

The number of S&E graduate students supported by nonfederal sources grew steadily in the eighties and has grown more sharply since, rising from 123,000 in 1983 to over 153,000 students in 1991. (See figure 2-19.) Most of this increase is due to a growth in the number of RAs provided by universities. (See "Support by Mechanism," below, and appendix tables 2-32 and 5-20.) Federal fellowships and other programs supported moderately increasing numbers of graduate students in S&E between 1983 and 1990, helping almost 58,000 graduate students by 1990. In 1991, federal support—like nonfederal—increased steeply, reaching an additional 6,000 students. Several agencies accounted for this increase, including the National Science Foundation and the National Institutes of Health and other Health and Human Services agencies.

Nonfederal sources provide the primary financial support for graduate students in all S&E fields except the computer sciences and psychology: Students in these latter fields have a high level of self-support. In terms of federal support, graduate students in the physical and life sciences receive the highest percentages, while students in mathematics and the social sciences receive the lowest. The ***number*** of students supported in mathematics, however, increased the most over the 1983-91 period, rising 9 percent annually. The lowest annual increase (0.9 percent) in federal support was in the environmental sciences. And in the social sciences, the number of students receiving federal support decreased annually by an average of 0.3 percent from an already low base. (See figure 2-20.)

Figure 2-19.

Major sources of support for science and engineering graduate students



See appendix table 2-32. *Science & Engineering Indicators – 1993*

Support by Mechanism. Fueled by growing university research funding, teaching assistantships and—especially—RAs have, over the last 12 years, displaced fellowships and traineeships as the major graduate support mechanism. (See figure 2-21.) By 1991, RAs and TAs were the most significant types of graduate student support: 27.5 percent of students' primary support came from RAs and 21 percent from TAs. Fellowships and traineeships accounted for 9 and 5 percent, respectively, of the primary support cited by graduate S&E students. (See appendix table 2-34.)

Use of these support mechanisms varies by S&E field. Eighty percent of graduate students in the physical sciences are supported by either RAs or TAs. These two mechanisms also represent key support mechanisms in the environmental and life sciences. However, RAs are a more important mechanism than TAs in engineering and the earth and life sciences, and are slightly more important in the physical sciences. TAs are more than twice as important as RAs in mathematics and the computer sciences. Only about a third of the students in psychology or the social sciences are supported by TAs or RAs. Fellowships and traineeships are not the key mechanism of support in any field, although students in the social sciences are as likely to be supported by a fellowship as by a research assistantship.

Support for Foreign Students.[38] Not surprisingly, the majority of funding support for foreign students at all levels of higher education is from non-U.S. sources. Personal and family sources provide primary funding

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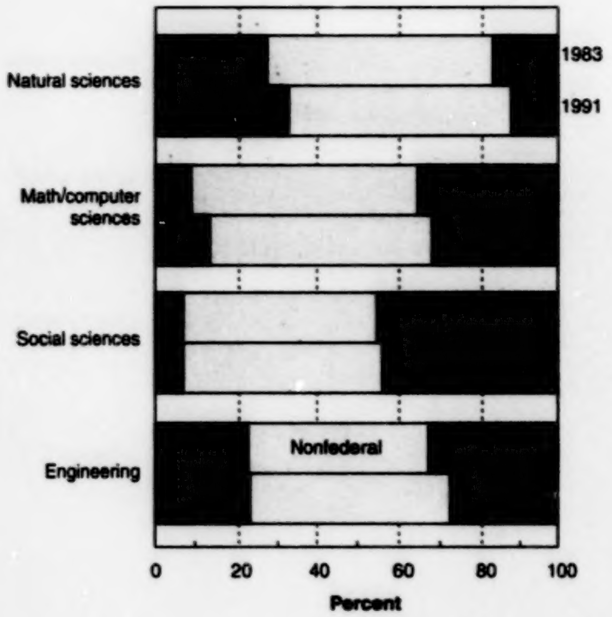
[37] Support from academic institutions includes university research funds from federal grants and contracts.

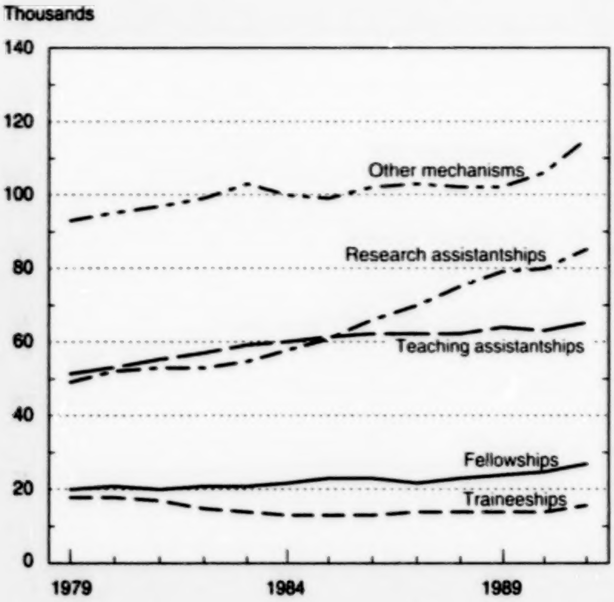
[38] Data on foreign student support at all levels are from IIE (1991); doctoral support data are from the National Science Foundation's Doctorate Records File. (See SRS 1993a.)

Figure 2-20.
Major sources of graduate student support, by field



See appendix table 2-33. *Science & Engineering Indicators – 1993*

Figure 2-21.
Major mechanisms of graduate support



See appendix table 2-34. *Science & Engineering Indicators – 1993*

support for 64 percent of foreign students; an additional 9 percent comes from their home governments, universities, and foreign private sponsors. U.S. sources are the primary funding support of only 27 percent of foreign students. This support is provided by U.S. colleges and universities (19 percent) and the U.S. Government (2 percent); 6 percent of foreign students cite employment and U.S. private sponsors as their primary support source (IIE 1991).

In striking contrast, U.S. sources are the primary funding support of 80 percent of all foreign doctoral S&E students. This is because U.S. universities subsidize the education of all S&E doctoral students—regardless of citizenship—in "hard" sciences (i.e., the natural sciences and engineering). Foreign doctoral S&E students are concentrated almost exclusively in these fields. Over three-quarters of foreign S&E doctoral students receive their primary funding support in the form of either RAs (including some research funds to universities from federal grants), TAs, or university fellowships. Three percent comes from federal fellowships or traineeships. About 20 percent of foreign doctoral S&E students cite various forms of self-support—family, loans, earnings, and spouse's earnings—as their primary funding support.

For U.S. citizens, about half of the primary support cited is from universities—again in the form of RAs, TAs, and university fellowships. About 13 percent of primary support cited by doctoral S&E students is from federal fellowships and traineeships. The remaining third of primary support is self-support, either through their own or their spouse's earnings, or through loans or family assistance.

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Chapter 3

Science and Engineering Workforce

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HIGHLIGHTS

INDUSTRIAL EMPLOYMENT OF SCIENTISTS, ENGINEERS, AND TECHNICIANS

- **U.S. industrial firms employed 1.3 million engineers and 667,000 scientists in 1992.** Between 1989 and 1992, total industrial science and engineering (S&E)employment increased at an average annual rate of 1.5 percent, considerably below the 3.6-percent rate registered during the preceding 9-year period.

- **The total number of S&E jobs in the manufacturing sector fell for the first time in more than a decade.** The number of jobs filled by engineers declined from 804,000 in 1989 to 767,000 in 1992. Four of the five largest engineering specialties and all five manufacturing industries employing the largest numbers of engineers had reductions.

- **In the late 1980s, the nonmanufacturing sector overtook the manufacturing sector as the leading employer of scientists and engineers.** More than 1 million scientists and engineers were employed in nonmanufacturing industries in 1992, a 12-percent increase over the 1989 level.

- **The total number of technician jobs in industry climbed steadily during the 1980s, reaching a total of 1.5 million in 1989.** Between 1989 and 1992, there was a cutback in technician jobs. Although there was a 3-percent gain in technician jobs in the nonmanufacturing sector, this increase was offset by an 11-percent decline in manufacturing industries.

S&E LABOR MARKET CONDITIONS

- **The 1992 unemployment rate for engineers was 3.8 percent; natural scientists, 2.3 percent; and mathematical and computer scientists, 2.6 percent.** Although scientists and engineers are less likely to be unemployed than other types of workers (the overall unemployment rate was 6.7 percent in 1992), these unemployment rates are higher than those recorded a couple of years ago. In addition, the unemployment rate for engineers is now higher than it was during the "aerospace recession" of the early 1970s.

- **Organizations that track entry-level hiring all report a reduction in employer recruiting of new college graduates in the 1990s.** Although all recent college graduates have been affected by the decrease in recruiting activity, S&E graduates are faring better than those who majored in other disciplines and are continuing to command higher starting salaries than their counterparts in non-S&E fields. The rate of increase in their starting salaries, however, slackened after 1990.

THE IMPACT OF DEFENSE DOWNSIZING ON S&E EMPLOYMENT

- **Reduced defense spending is adversely affecting engineering employment.** Recent government projections show that more than two out of five engineering, defense-related, civilian jobs have been or will be lost between 1987 and 1997. Engineers who have spent their entire careers working in the defense industry and have become highly specialized may have difficulty finding civilian sector jobs.

- **Defense downsizing has affected industry's employment of R&D scientists and engineers.** The total number of full-time-equivalent R&D scientists and engineers working for industrial firms declined from 730,000 in 1990 to 684,900 in 1992. In the aircraft and missiles industry, the number of federally supported research and development scientists and engineers declined 20 percent in the early 1990s.

ENGINEERING EMPLOYMENT

- **Recent trends in U.S. engineering employment show a loss of 50,000 jobs between 1987 and 1992; the unemployment rate doubling; and sluggish growth in salaries relative to those earned in other professions.** The engineering workforce is currently feeling the pinch of the recession, cutbacks in defense spending and research and development, and industry downsizing. If there is a substantial amount of defense conversion, however, the loss in defense jobs may be offset by the creation of new opportunities in emerging industries.

- **The engineering specialties most adversely affected by the slow economy and lower defense budgets are electrical and electronic, industrial, and aerospace.** Other engineering specialties—environmental, civil, chemical, petroleum, systems, and software—appear relatively more immune to the recession and defense cutbacks.

FORECASTING THE S&E JOB MARKET

- The most recent studies of the future S&E job market (that take into account defense downsizing) yielded the following conclusions for 1990-2005. Employment in technical occupations will grow at a faster pace than overall employment. Employment in technology-intensive industries will grow at about the same rate as employment in general; and surpluses are more likely to be observed in the S&E job market than shortages, but the latter (especially in specific fields) cannot be ruled out.

DOCTORAL SCIENTISTS IN THE WORKFORCE

- **In 1991, approximately 367,000 doctoral scientists and 70,000 doctoral engineers were employed in the United States.** Doctoral scientists had an extremely low unemployment rate—1.5 percent in 1991. Recently, however, their professional associations have been documenting employment difficulties faced by new doctoral recipients, focusing on the lack of permanent full-time job openings in academia.

WOMEN AND MINORITIES IN THE S&E WORKFORCE

- **Women, blacks, and Hispanics are underrepresented in the engineering workforce and some of the physical sciences, e.g., physics and geology. Some progress has been made, however, over the past decade.** Between 1983 and 1992, the percentage of women in the engineering workforce increased from 5.9 percent to 8.7 percent, the percentage of blacks increased from 2.6 percent to 4.0 percent, and the percentage of Hispanics increased from 2.2 percent to 3.1 percent.

- **Women comprised 18.8 percent of the doctoral S&E workforce in 1991.** While women are well represented in psychology and fairly well represented in the social and life sciences, they accounted for only 3.4 percent of all doctoral engineers in 1991.

IMMIGRANTS IN THE S&E WORKFORCE

- **The flow of S&E immigrants to the United States reached an all-time high of nearly 23,000 in 1992.** Most of these immigrants were born in the Far East, primarily in India, China, and Taiwan. In addition, unprecedented numbers of scientists and engineers from the former Soviet Union entered the United States in 1991 and 1992, accounting for almost 2,400 visas in those 2 years.

Introduction

Chapter Background

The United States produces, nurtures, and maintains the largest science and engineering (S&E) workforce in the industrialized world. According to the most recent government projections, employment in technical occupations will grow at a faster pace than overall employment during the rest of this century and past the year 2000. But in the early 1990s, the recession, defense-related spending cutbacks, reduced research and development (R&D) budgets, and industry downsizing all took their toll on S&E employment. Manufacturing S&E employment declined for the first time in more than a decade; unemployment rates rose; recruiting of recent college graduates declined; entry-level salaries stagnated; and overall salary growth did not keep pace with that of other professional occupations. Despite these trends, scientists and engineers have fared better than almost every other kind of worker. The tight labor market has not precluded some S&E-trained individuals from finding meaningful, challenging work opportunities outside traditional S&E occupations.

The contribution of scientists and engineers to a healthy and competitive economy is vastly disproportionate to their (less than 4 percent) representation in the total labor force, because they are responsible for the advancements in science and technology that lead to new/improved products and processes that in turn lead to economic expansion and the universally sought-after higher standard of living. In addition, their value to society has been accelerating when measured against a backdrop of a worldwide economy in which the pace of technological change is moving rapidly; competition in the international marketplace is intensifying; and the quest for solutions to health, environmental, and a host of other worsening societal problems is becoming increasingly urgent.

Chapter Organization

This chapter begins with a discussion of S&E employment by sector. Employment of scientists, engineers, and technicians in the industrial sector is examined, followed by a discussion of scientists and engineers employed by the Federal Government. (This chapter does not contain a specific section devoted to scientists and engineers employed by colleges and universities, because they are covered in chapter 5.) Other topics examined are scientists and engineers engaged in research and development in the United States and R&D employment by U.S. companies in other countries.

This chapter also covers the S&E labor market, including the impact of defense downsizing on technical employment and recent efforts to forecast the supply and demand for technical workers. Separate sections are devoted to employment trends among doctoral scientists and engineers and special populations in the S&E workforce, including women, minorities, and immigrants. Finally, comparative data on international S&E employment are provided.

S&E Employment by Sector

Industrial S&E Employment

Most scientists and engineers work in industry. In 1992, there were nearly 2 million industrial S&E jobs, with engineers outnumbering scientists two to one (BLS' annual series). (See appendix table 3-1.)[1]

The rate of growth in industrial S&E employment slowed considerably in the early 1990s. Between 1989 and 1992, total industrial S&E employment increased at an average annual rate of 1.5 percent, far below the 3.6 percent rate registered between 1980 and 1989. Despite the slowdown, the rate of growth in industrial S&E employment outpaced that for total industrial employment, continuing a trend that began before 1980. Between 1980 and 1992, the S&E share of total industrial employment gradually increased, rising from 2.1 percent in 1980 to 2.5 percent in 1992.

The major contributing factor to the increase in industrial S&E employment between 1980 and 1992 was a doubling in the number of jobs filled by computer specialists. This group now accounts for more than half of all scientists employed by industry. Their proportion of total industrial S&E employment increased from 13 percent in 1980 to 18 percent in 1992.

Industrial S&E Employment in Manufacturing

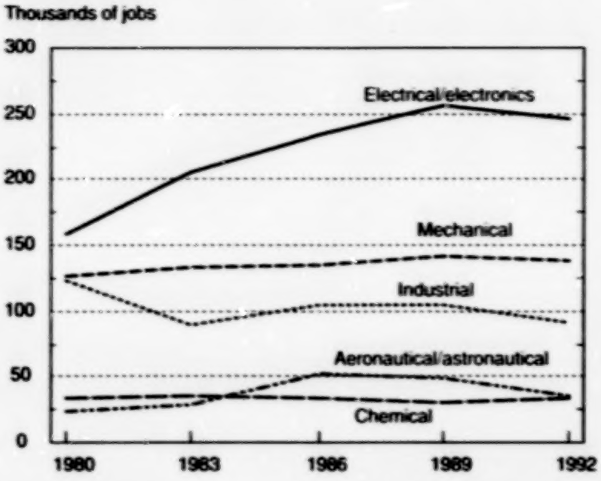
Manufacturing Employment of Engineers. The total number of engineering jobs in the manufacturing sector fell for the first time in more than a decade. In 1992, there were 767,000 engineering jobs in manufacturing, down nearly 5 percent from the level recorded 3 years earlier. This cutback in engineering employment ended an extended period of engineering job creation. Between 1977 and 1989, the total number of engineering jobs in manufacturing increased nearly 60 percent.

In general, the decline in engineering employment in manufacturing in the early 1990s was across the board. Four of the five largest engineering specialties, and the five manufacturing industries employing the largest numbers of engineers, had reductions. (See figures 3-1 and 3-2 and "Engineering Employment in the '90s.")

Among the five largest engineering specialties, the largest percentage cutback was in *aeronautical/astronautical engineering*. In this specialty, the total number of jobs fell 26 percent between 1989 and 1992. The entire loss appears to have occurred in the transportation equipment industry, which is the largest employer of aeronautical/astronautical engineers. Many of these engineers were working for aircraft and missiles companies and were assigned to defense-related projects that are being curtailed or eliminated. (See "The Impact of Defense Downsizing on Technical Employment.")

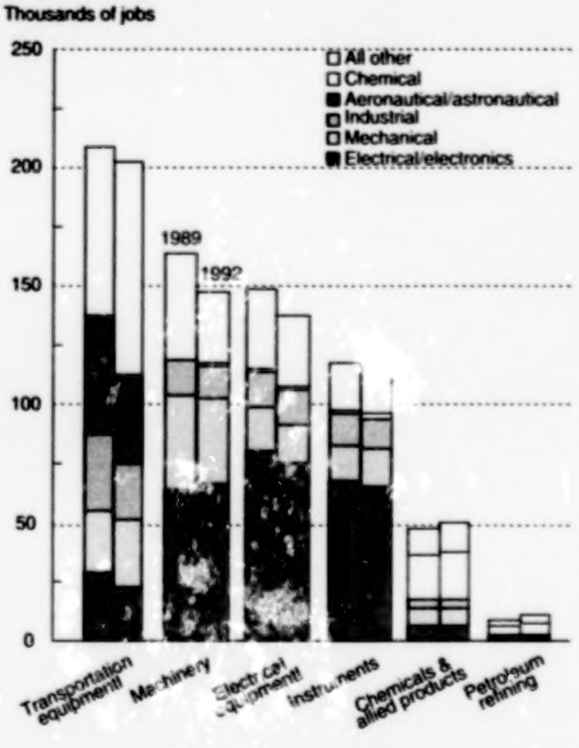
Job losses in *industrial engineering* numbered 13,000 between 1989 and 1992, the largest absolute decline of any engineering specialty. The transportation equipment industry, the largest employer of industrial engineers in the late 1980s and early 1990s, accounted for 70 percent of the decrease in industrial engineering jobs in manufacturing.

Figure 3-1.
Number of jobs in manufacturing for selected engineering specialties



See appendix table 3-1. *Science & Engineering Indicators – 1993*

Figure 3-2.
Number of engineering jobs in selected manufacturing industries



See appendix table 3-1. *Science & Engineering Indicators – 1993*

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[1] The data in this section were collected by the Bureau of Labor Statistics in its Occupational Employment Survey.

Engineering Employment in the '90s

The engineering specialties most adversely affected by the slow economy and lower defense budgets are electrical and electronic, industrial, and aerospace. Job losses among these categories amounted to an estimated 41,000, 25,000, and 23,000, respectively, between 1987 and 1992. (See appendix table 3-7.) Of these three, aerospace registered the highest percentage loss of jobs, 22 percent, during the late 1980s and early 1990s. Not surprisingly, there has been a drastic decline in job offers to recent aerospace engineering graduates.[*]

Other engineering specialties appear relatively more immune to the recession and defense cutbacks:

- **Environmental engineers:** Enactment of tougher environmental laws and regulations has increased the demand for engineers with expertise in toxic waste disposal, hazardous material handling, and emissions control. They are also serving as consultants, advising companies on how to minimize the cost of compliance with environmental laws and regulations.
- **Civil engineers:** The need for increased investment in public works and the repair/rebuilding of the aging infrastructure, e.g., subway systems, bridges, and buildings, in many U.S. cities appears to have boosted demand for civil engineers.
- **Chemical and petroleum engineers:** Demand for these engineers has led that for all other engineering specialties for the past several years. The scarcity of graduates in these two specialties is reflected in their starting salaries which are higher than those received by any other recent graduates (and which also showed the largest percentage gains between 1988 and 1993). The petroleum refining industry, one of the leading employers of these two types of engineers, has been less affected by the recession than most other industries.
- **Systems and software engineers:** Their services are in great demand, not only in software companies, but also in hardware firms where emphasis on state-of-the-art technology is increasingly shifting from hardware to software (Engineering Manpower Commission 1992b). In addition, because of the application of computer technology across all sectors of the economy, demand for software engineers shows no sign of slowing.

Several recent trends in engineering employment should be noted:

- Demand for engineers has infiltrated almost every industry, from manufacturing to the service sector. Their computer, quantitative, and problem-solving skills provide entree to various industries, including consulting and other types of service sector firms.[**]
- The increasing use of computer-aided design and computer-aided manufacturing (CAD/CAM) systems and other automation tools has brought about major improvements in productivity across all sectors of the economy. These technological advances have also resulted in improved productivity in the engineering profession itself, because the amount of (engineering) labor needed to perform certain tasks has been falling. For example, no one doubts that rebuilding the aging infrastructure will sustain strong demand for civil engineers throughout the 1990s. But this demand could be partially offset by increased use of CAD/CAM systems (Engineering Manpower Commission 1991a). In addition, the increasing use of automation allows technicians and other paraprofessionals to be more easily substituted for engineers.

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[*] For example, recent CalTech engineering graduates did not receive a single job offer from any of the major aerospace companies in Southern California (Engineering Manpower Commission 1992b).

[**] At least one quarter of the 1,600 new graduates hired in 1992 by Anderson Consulting, the information systems consulting arm of the Arthur Anderson accounting firm, majored in engineering. See Engineering Manpower Commission (1992b).

Ten thousand *electrical/electronics engineering* jobs were lost between 1989 and 1992. The largest cutbacks were—again—in the transportation equipment industry, and also in the electrical equipment industry. These losses amounted to 6,000 and 5,000 jobs, respectively. There was, however, a small increase in electrical/electronics engineers in the machinery industry.

There were fewer *mechanical engineering* jobs in 1992 than 3 years earlier. Reductions amounting to 3,000 jobs in the machinery industry and 2,000 in the electrical equipment industry were only partially offset by increases in the transportation equipment and instruments industries.

Of the five largest engineering specialties, only *chemical engineering* showed a gain for the 1989-92 period. Employment in this field had been declining during the mid- and late 1980s, but a turnaround in the early 1990s increased the total number of jobs in this field by 9 percent between 1989 and 1992.

Manufacturing Employment of Scientists. Unlike engineering, the total number of scientists' jobs in manufacturing increased during the early 1990s, but at a much slower pace than that registered during the mid- and late 1980s. There were approximately 9,000 more scientists working for manufacturing firms in 1992 than in 1989.

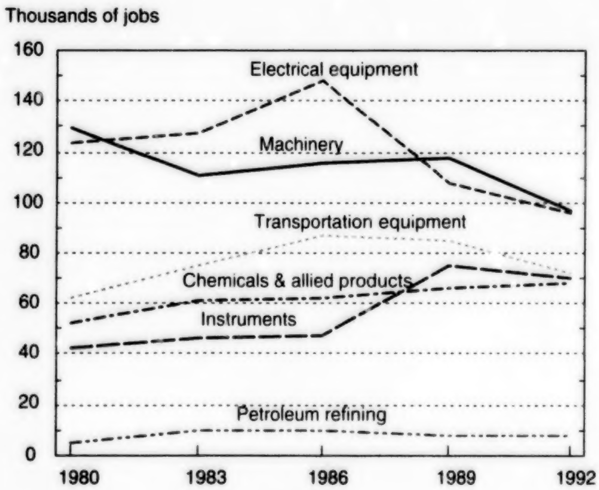
During that 3-year period, the number of biological scientists increased by 6,000, or 46 percent. Most of this increase occurred in the chemicals and allied products industry which includes drug manufacturers. This large increase, and a modest increase in the number of computer specialists, however, were offset by small declines in other scientific specialties, including chemistry and the mathematical sciences.

Manufacturing Employment of Technicians. Overall, there was a more than 10-percent decline in the total number of technician jobs in manufacturing between 1989 and 1992. The four largest groups within this category—electrical/electronics engineering technicians, drafters, computer programmers, and chemical technicians—all had reductions. The largest declines were in electrical/electronics engineering and computer programming, with job losses amounting to 23,000 and 21,000, respectively, between 1989 and 1992. As with engineers, the loss in technician jobs was widespread across industries. For example, the four manufacturing industries employing the largest numbers of technicians all had reductions between 1989 and 1992. The losses ranged from a reduction of 21,000 positions in the machinery industry to a loss of 5,000 positions in the instruments industry. (See figure 3-3.)

Industrial S&E Employment in Nonmanufacturing

In the late 1980s, the nonmanufacturing sector overtook the manufacturing sector in terms of total S&E employment. This changeover is largely attributable to growth in the number of jobs for computer specialists. In 1980, computer specialists accounted for one out of every five scientists and engineers employed in the nonmanufacturing sector; in 1992, they accounted for nearly one out of four.

Figure 3-3.
Number of technician jobs in selected manufacturing industries



See appendix table 3-1. *Science & Engineering Indicators – 1993*

Nonmanufacturing Employment of Engineers. There were nearly 600,000 engineering jobs in the nonmanufacturing sector in 1992. In contrast to the decline in engineering employment in the manufacturing sector in the early 1990s, the number of jobs in the nonmanufacturing sector increased 8 percent between 1989 and 1992. Most of the gain occurred in the engineering and computer services industries.

Nonmanufacturing Employment of Scientists. In 1992, the nonmanufacturing sector employed approximately 460,000 scientists, a 16-percent increase over the level recorded for 1989. More than half these jobs were filled by computer specialists; the total number of these scientists increased 10 percent between 1989 and 1992. The number of jobs in the other scientific specialties, although far fewer in number than those for computer specialists, had higher rates of growth during the 1989-92 period, ranging from nearly 40 percent for social scientists to 16 percent for mathematical scientists.

Nonmanufacturing Employment of Technicians. The total number of technicians employed by the nonmanufacturing sector increased from 920,000 in 1989 to 950,000 in 1992. Most of this increase occurred in the computer services industry which gained 18,000 technician jobs during this period.

Federal S&E Employment

The Federal Government employed approximately 170,000 scientists and 115,000 engineers in 1991, making it the single largest employer of scientists and engineers in the United States (OPM 1985, 1991).[2] (See appendix table 3-2.) Over one-fourth of the scientists and engineers employed by the government are engaged in research and development; this segment of the federal S&E workforce is concentrated in laboratories run by the Departments of Defense (DOD), Agriculture, Health and Human Services; and the National Aeronautics and Space Administration (NASA). The other three-fourths of the federal S&E workforce are responsible for managing natural resources; data collection and statistical analysis; development, implementation, and enforcement of government regulations; construction of public works projects; testing and evaluation; and administration of S&E activities (NRC 1993, p. 17).

The Department of Defense is the government's largest employer of both scientists and engineers, accounting for one out of every three federally employed scientists and two out of every three engineers. (See figure 3-4.) In general, the impact of defense downsizing on S&E employment

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[2] These data were collected by the Office of Personnel Management. The numbers do not include scientists and engineers working at federally funded research and development centers, or those working at organizations (e.g., colleges and universities, national laboratories, or industrial firms) that receive federal grants and contracts. For additional information on how these data were collected, see SRS (1989).

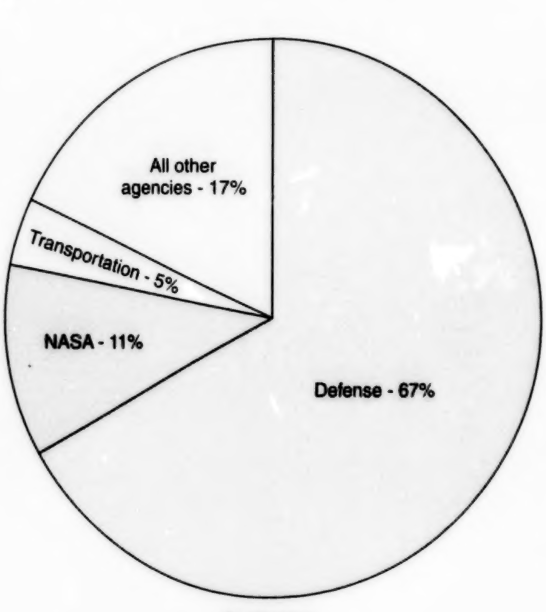
(see "The Impact of Defense Downsizing on Technical Employment") is not yet reflected in government employment statistics (just as it is not yet reflected in federal R&D expenditure data—see chapter 4). Between 1985 and 1991, DOD's employment of scientists and engineers increased 8 and 11 percent, respectively. During this period, however, there were cutbacks in several S&E fields, including mathematics and statistics and civil, industrial, and chemical engineering.

Employment of Scientists. Between 1985 and 1991, the number of scientists employed by the Federal Government increased about 16 percent. Most of this growth was fueled by a 32-percent increase in the employment of computer scientists. By 1991, this group outnumbered all other S&E occupational groups, accounting for 53,000 federally employed scientists. Half these computer scientists were employed by DOD. The Treasury Department had the second highest number (5,300). Employment of computer scientists by this agency increased 83 percent between 1985 and 1991.

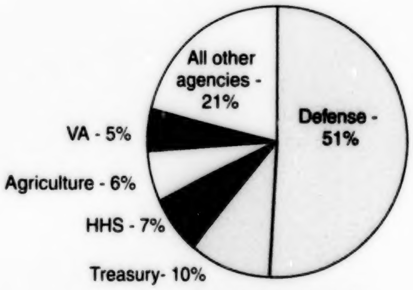
Life scientists are the second most prevalent S&E group within the federal workforce. Three out of five of the more than 37,000 scientists classified in this occupational group in 1991 were employed by the Agriculture Department. The Interior Department had the second highest number (5,700), followed by Health and Human Services (3,300). The latter had a 46-percent gain over the number reported in 1985. There was an across-the-board increase in Health and Human Services programs during the late 1980s; a substantial part of the growth in employment of life scientists is probably attributable to increased funding for the National Institutes of Health's health research on AIDS and other diseases. (See chapter 4.)

Employment of Engineers. Total federal employment of engineers increased 12 percent between 1985 and 1991. The most prevalent engineering specialty within the federal workforce—accounting for over 30 percent of the total number of engineers—is the electrical and electronics subfield. NASA, which employed 12,000 engineers in 1991, ranks a distant second to DOD in engineering employment. NASA, however, increased its hiring of engineers 30 percent between 1985 and 1991.

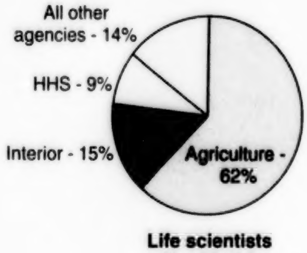
Figure 3-4.
Federally employed scientists and engineers, by agency: 1991



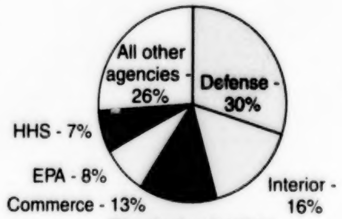
Engineers
N = 114,871



Computer scientists
N = 53,097



Life scientists
N = 37,437



Physical scientists
N = 32,556

See appendix table 3-2. *Science & Engineering Indicators – 1993*

R&D Employment

R&D Employment in the United States

In 1989, an estimated 950,000 scientists and engineers were employed on a full-time-equivalent (FTE) basis in R&D in the United States. Approximately three-fourths of these R&D professionals were employed by industrial firms, roughly 18 percent by academic institutions, and 6 percent by federal agencies (SRS 1992b, pp. 29 and 63). (See appendix table 3-3.)

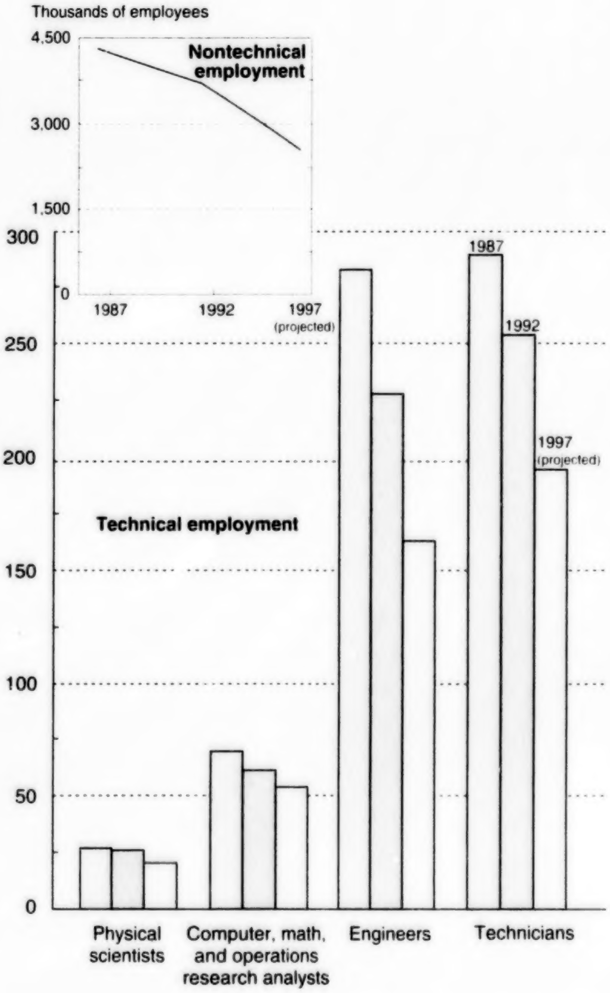
The rate of increase in R&D spending in the United States slowed after 1985 (see chapter 4, "National R&D

The Impact of Defense Downsizing on Technical Employment

The end of the Cold War has meant a dramatic curtailment in overall defense spending (see chapter 4 for a discussion of defense R&D funding) that has adversely affected S&E employment. Defense cutbacks began in 1988 and are likely to escalate during the next few years. Therefore, the full impact of the "peace dividend" on S&E employment is unknown. Bureau of Labor Statistics (BLS) estimates made in early 1993 show the United States losing more than 700,000 defense-related civilian jobs between 1987 and 1992, and an additional 1.3 million jobs between 1992 and 1997—a 40-percent reduction over the 10-year period (Saunders 1993, p. 3). (See figure 3-5 and appendix table 3-10.)

Although scientists and engineers comprise only 3 to 4 percent of the total U.S. labor force, they account for a higher proportion—8 to 9 percent—of all defense-related civilian employment. (Technicians account for an additional 6 percent of defense-related civilian employment.) In 1987, approximately 16 percent of the engineers and 11 percent of the (natural, computer, and math) scientists working in the United States were involved in defense work. Those percentages dropped to 13 and 8 percent, respectively, in 1992.

Figure 3-5.
Defense-related employment



See appendix table 3-10. *Science & Engineering Indicators – 1993*

Engineers are heavily represented in industries that produce military-related hardware and software. In the aerospace industry, they accounted for one-fifth of all jobs, and in the electronic components and communication equipment segments of the electrical equipment industry, they held 12 percent of all jobs in 1992. So engineers working in these industries are more likely to have their job security threatened than those working in other industries (Engineering Manpower Commission 1991a). The percentage of the total engineering workforce involved in defense-related work, however, is much lower today than it was 25 years ago. The number of engineers employed by the Department of Defense and prime and subcontractors in 1990 was only slightly higher than the number employed in 1967 (at the height of the Vietnam buildup). In contrast, during the same period (1967-90), the total number of engineers increased about 50 percent (R. Rivers, cited in Bell 1990, p. 39).

Engineering is one of the fields most affected by the defense drawdown. According to BLS projections, 120,000—or more than two out of five engineering defense-related jobs—have been or will be lost between 1987 and 1997. Most of the losses have occurred or will occur in the electrical/electronics, aeronautical/astronautical, mechanical, and industrial engineering specialties. Another hard-hit group will be those employed in computer, mathematical, and operations research specialties, where the total number of jobs is expected to decline from 69,800 in 1987 to 54,500 in 1997. Physical scientists have experienced or will experience fewer job losses—a total of 6,700 during the 10-year period—but this number represents one-fourth the total number of defense-related jobs that existed in 1987. Technician employment is expected to decline by one-third over the 10-year period. (See figure 3-8.)

R&D employment is also being adversely affected by defense budget cutbacks. The number of federally supported FTE R&D scientists and engineers working for firms classified in the aircraft and missiles industry (the largest employer of federally funded R&D personnel) declined 20 percent between 1989 and 1991. Employment of these R&D professionals declined 6 percent in the electrical equipment industry (the second largest employer) and 47 percent in the machinery industry during the same 2-year period (SRS forthcoming [b]).

For perspective, it is important to emphasize that given the size of the U.S. economy, defense downsizing is "unlikely to cause a short-run macroeconomic catastrophe" (Brauer and Marlin 1992, p. 148). Fewer than 1 percent of all U.S. workers will be affected over the next 5 years (Kosiak and Bitzinger, 1993). Only a few pockets of the economy, i.e., only a few industries, occupations, and communities, are likely to suffer measurable injury. For example:

- Some companies currently producing military hardware will be unwilling or unable to convert to products for the civilian market. Some companies have already chosen to downsize rather than venture into new markets. (See *Washington Post* 1992.)
- Some engineers who have spent their entire careers in the defense industry—those who have become highly specialized—may have difficulty finding civilian sector jobs. (Defense workers also tend to be older; this, despite their job experience, makes them less desirable for retraining and employment by civilian firms. See OTA 1992). Finding another job is also likely to mean relocation, a condition some unemployed engineers have been unwilling to accept (Engineering Manpower Commission 1991a).
- Some regions of the country—those most heavily dependent on the defense industry—will experience at least a short-term expansion of their unemployment rolls. The states most adversely affected are Washington, California, Arizona, Texas, Missouri, and almost all New England states; the DC-Maryland-Virginia area and Long Island, New York, are also likely to suffer the consequences of reduced military budgets. For some regions, such as the Los Angeles area, the defense cutbacks will continue to exacerbate an already severe unemployment problem; while others with more diversified economies are unlikely to experience as much hardship (Brauer and Marlin 1992).

The expected unemployment of scientists, engineers, and technicians brought about by the end of Cold War hostilities is likely to be mitigated by *defense conversion*—i.e., federal support shifted from military to civilian technology advancement may mean that the loss in defense jobs will be offset by the creation of new opportunities in emerging industries—and by increased demand for highly skilled workers to maintain international competitiveness (Atkinson 1990). (See chapter 4 for a discussion of various defense conversion projects and programs.)

Spending Patterns.) The average annual rate of increase in inflation-adjusted national R&D expenditures was 1.9 percent between 1985 and 1989, compared to 6.6 percent between 1980 and 1985. There was a corresponding slowdown in the rate of increase in R&D S&E employment during this period, with the average annual rate dropping from 5.3 percent during the first half of the decade to 3.1 percent between 1985 and 1989.

Although R&D scientists and engineers comprise less than 1 percent of the U.S. labor force, the rate of growth in the number of these professionals has been exceeding that for the entire U.S. labor force. As a result, the R&D S&E proportion of the U.S. labor force has been increasing steadily since the mid-1970s—from 55 R&D scientists and engineers per 10,000 labor force population in 1976 to 76 in 1989. (See figure 3-17.)

Industry's employment of R&D scientists and engineers declined in the early 1990s—from 730,000 in January 1990 to 684,000 in January 1992 (SRS forthcoming [b]). Defense downsizing appears to be causing a reduction in the number of industrial scientists and engineers assigned to government R&D contracts. (See "The Impact of Defense Downsizing on Technical Employment.")

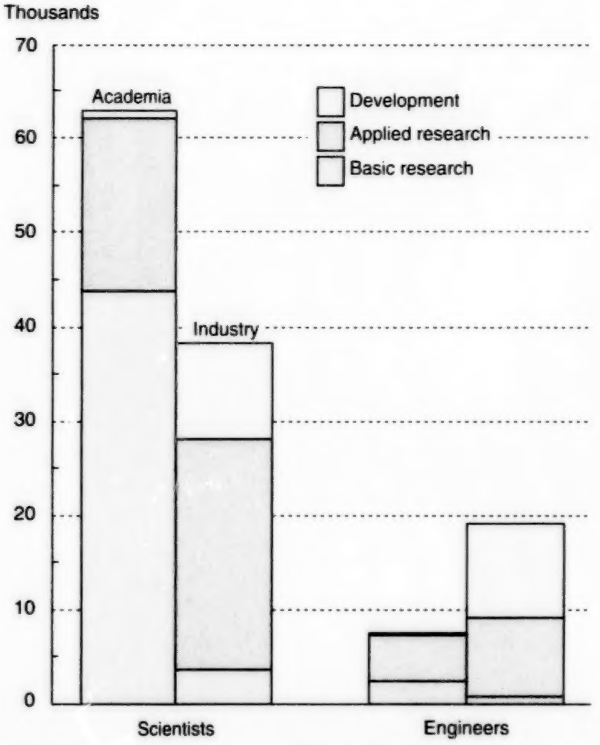
Nearly half the doctoral scientists and engineers employed by industrial firms, and over a third of those employed by academic institutions, were primarily engaged in the conduct of research and development in 1991. (See appendix table 3-4.) In industry, most R&D scientists with doctoral degrees work in applied research; most R&D engineers are assigned to development activities. In academia, most doctorate-holding scientists primarily engaged in R&D are working on basic research projects; most engineers are involved in applied research. (See figure 3-6.)

R&D Employment by U.S. Companies in Other Countries

Industrial R&D is becoming increasingly globalized. U.S. companies' expenditures on R&D performed outside the United States rose dramatically during the 1980s (see chapter 4). A myriad of factors is responsible for the upsurge in R&D spending abroad. Companies are compelled to conduct more R&D outside the United States to compete in rapidly expanding worldwide markets. To obtain or expand overseas sales, it has become increasingly necessary to tailor products to meet specific needs and requirements of foreign customers. In addition, U.S. companies have been acquiring laboratories in other countries at a record pace—especially in Japan, but also in Europe, other Asian countries, and Canada. Foreign workers' competence, technical skills, and affordability are some of the factors influencing the decisions to build and/or acquire existing foreign laboratories.

In 1989 (the most recent year for which data are available), total R&D employment (including scientists, engineers, managers, and other professional and technical

Figure 3-6.
Doctoral scientists and engineers primarily engaged in R&D: 1991



See appendix table 3-4. *Science & Engineering Indicators – 1993*

employees) by U.S. companies in other countries reached 95,000—7.6 percent higher than the level reported in 1982.[3] (See appendix table 3-5.) Most of these R&D employees—71 percent in 1989—are located in Europe. Germany and the United Kingdom had the highest numbers of U.S. R&D employees—24,000 and 20,000, respectively. (See figure 3-7.)

In 1982, 4.3 percent of employees working for U.S. affiliates in Germany were engaged in R&D, the highest proportion of any country; Japan ranked second at 3.8 percent. But U.S. companies' R&D employment in Japan increased more than 150 percent between 1982 and 1989, the highest rate of growth reported for any country. Thus, by 1989, the proportion of U.S. Japanese affiliates' total employment engaged in R&D had risen to 5.9 percent, the highest of any country.[4] The United Kingdom had a reduction (13 percent) in R&D employment by U.S. affiliates between 1982 and 1989.

The leading industry in terms of R&D employment abroad in 1989 was transportation equipment (20,400 employees); it was followed by the chemicals and allied products industry with 18,700 R&D employees. (See figure 3-6 and appendix table 3-6.) The office and computing machines segment of the machinery industry had the largest absolute increase—5,300 employees—in R&D employment in the mid- and late 1980s (84 percent higher than the R&D employment level reported in 1982). In the nonmanufacturing sector, R&D employment in the finance and services industry nearly doubled between 1982 and 1989, rising from 3,600 to almost 7,000 employees.

Several industries had reductions between 1982 and 1989 in R&D employment abroad by U.S. affiliates. The largest decline—5,700 employees—occurred in the electrical equipment industry.

In most industries, R&D employment grew at a faster pace than overall employment by U.S. affiliates. All segments of the chemicals industry and the office and computing machines segment of the machinery industry had the largest increases in this measure of R&D intensity.

S&E Labor Market Conditions

A few years ago, reports of impending S&E personnel shortages were common.[5] More recently, however, the focus has been on possible surpluses, because the recession, downsizing of the defense industry (see "The Impact of Defense Downsizing on Technical Employment"), and (to a lesser extent) immigrant scientists and engineers from the former Soviet Union and Eastern Bloc countries are all currently disrupting the U.S. S&E labor market.

Predictions of shortages or surpluses of S&E personnel should be treated with caution. At any point in time, for any field, there may be shortages or surpluses. But in a free market economy, these shortages or surpluses are eventually eliminated. U.S. labor markets are flexible—changes in supply and demand trigger fairly quick responses in terms of both degree production and mobility within the labor force. Moreover, employers can be expected to deploy a number of strategies to avert a prospective labor shortage.[6]

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[3] Data in this section were collected by the Bureau of Economic Analysis in its 1982 and 1989 Benchmark Surveys of U.S. Direct Investment Abroad. Data on R&D employment are collected only in "benchmark" survey years; 1982 and 1989 are the two most recent years for which data are available. For more detailed information about the methodologies and definitions used in conducting these surveys, see BEA (1985 and 1992).

[4] According to one study, the primary reason U.S. companies have been establishing laboratories in Japan is to develop products specifically for the Japanese market (SRS 1991).

[5] For example, Atkinson (1990) noted that "all the models that are used to project supply and demand for scientists and engineers, although differing on quantitative details, come to the same fundamental conclusion: that unless corrective actions are taken immediately, all sectors of society will begin to experience shortages of scientists and engineers in the next 4 to 6 years, with shortages becoming significant during the early years of the next century." And, in 1989, 67 percent of the member companies responding to an Aerospace Industries Association survey reported current shortages of scientists and engineers; 85 percent anticipated shortages in the future (Aerospace Industries Association 1989).

[6] For example, they can lower hiring standards by eliminating advanced degree requirements, employing individuals trained in related fields, or assigning more responsibilities to technicians. In industry in particular, transferring individuals from one specialty to another, revising degree requirements for particular positions, and retaining are routine. Employers can also increase their hiring of immigrants, or they can move their operations offshore to countries that have a plentiful supply of workers with the skills they need.

S&E labor markets are more flexible in some ways than those for other occupations. Scientists and engineers are generally highly trained and well-educated in analytically based fields. This background can serve them well in a wide array of non-S&E occupations. An increasing number of scientists and engineers in fact have been pursuing careers in business, law, and other professions—occupations that have a growing need for their expertise (Holden 1991).

S&E labor markets are also less flexible in some ways than those for other occupations due in part to the long educational pipeline. When the demand for S&E personnel exceeds the supply, employers usually increase salary levels in an effort to attract the workers they need. Rising salaries tend to induce more students to study in fields with shortages, thus eventually increasing supply. But because of the time it takes to complete a formal education, the demand/supply imbalance may persist for several years, stretching out even longer if the unmet need is for doctoral scientists and engineers.

S&E Unemployment and Underemployment

Although scientists and engineers are less likely to be unemployed than other types of workers (the overall 1993 third quarter unemployment rate was 5.9 percent), S&E unemployment rates have been increasing for the past couple of years,[7]—especially among engineers (see "Engineers: Shifting Employment Opportunities and Trends")—and are higher than those for other professional specialty occupations, including physicians, lawyers, and teachers. (See appendix table 3-11.) The 1993 (third quarter) unemployment rate for all engineers stood at 3.8 percent; for all natural scientists, it was 3.0 percent; and for all mathematical and computer scientists, it was 2.2 percent. (See figure 3-9.)

In addition to unemployed scientists and engineers, there are also ***underemployed*** S&E professionals. Although data on S&E underemployment are scarce, the most recent data on doctoral underemployment suggest that few Ph.D. scientists and engineers—fewer than 2 percent—are underemployed (SRS forthcoming [a]).[8]

New S&E Entrants

The most recent information on entry-level hiring indicates that the demand for college graduates fell sharply during the 1990s.[9] Organizations that track entry-level hiring of college graduates all report a reduction in recruiting by employers and in the number of job offers made to new bachelors degree

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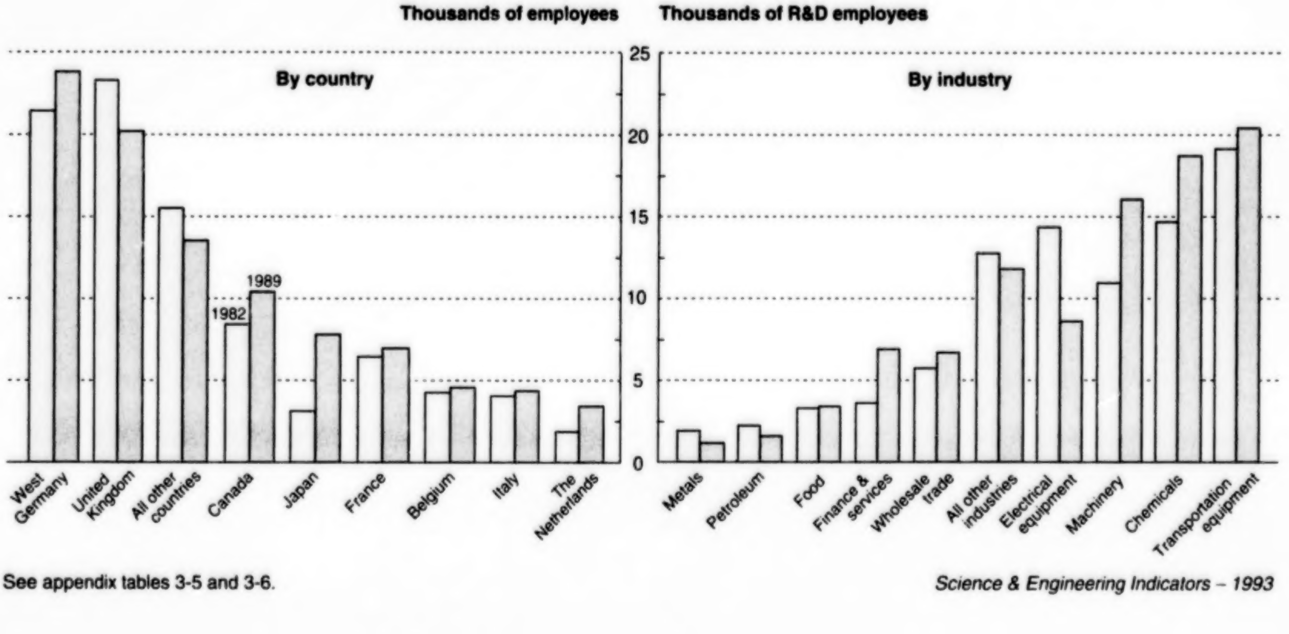
[7] In the most recent American Chemical Society survey, 1.9 percent of the respondents reported that they were without jobs but seeking employment, the highest unemployment rate registered by this survey since 1983, when a 2.2-percent unemployment rate was recorded. See Brennan, Rawls, and Zurer (1992).

[8] The definition of underemployment used here refers to doctorate-holding scientists and engineers who are either (1) holding part-time positions when they would have preferred working full time, or (2) working in non-S&E occupations when they would have preferred S&E jobs.

[9] BLS analyses and forecasts predict that the number of college graduates working in jobs traditionally not requiring a 4-year college degree will increase during the 1990s and into the next decade. See Shelley (1992) and Hecker (1992).

Figure 3-7.
R&D employment by foreign affiliates of U.S. companies



See appendix tables 3-5 and 3-6.

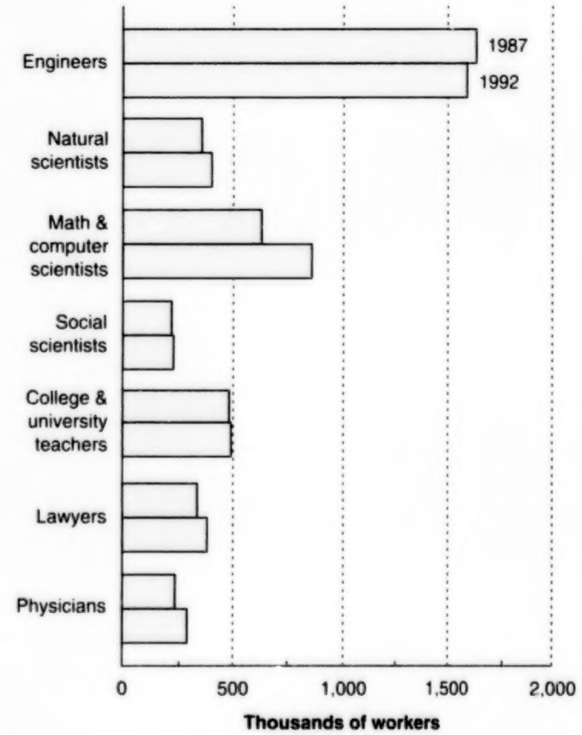
Science & Engineering Indicators – 1993

Engineers: Shifting Employment Opportunities and Trends

An estimated 1.6 million people were employed as engineers in the United States in 1992. The engineering workforce contracted during the late 1980s and early 1990s, losing nearly 50,000 members between 1987 and 1992. (See figure 3-8.) At the same time, the unemployment rate for engineers doubled, increasing from the traditional level of around 2 percent to 3.8 percent in the third quarter of 1993. (See appendix table 3-11.) The unemployment rate for engineers is now higher than it was during the "aerospace recession" of the early 1970s and is also higher than the 2.8-percent unemployment rate for all professional specialty occupations combined. In addition, recent engineering graduates are having more difficulty than their 1980s predecessors in landing their first jobs.* But despite the weaker employment conditions faced by new engineering graduates, hardly any are forced to join the ranks of the unemployed, and compared to graduates who majored in other disciplines, they are better off in terms of the number of employment offers and in the salaries they receive.

All of these observations—the shrinking workforce, the rising unemployment rate, and the falloff in employer recruiting—indicate that the engineering profession is currently feeling the pinch of the recession, cutbacks in defense spending, and industry downsizing. These numbers, plus the sluggish growth in salaries relative to other professional occupations, could discourage students from seeking engineering careers. Engineering training, however, can be a useful entree into nonengineering jobs. In addition to engineers' key role in innovation and the design, production, and marketing of new/improved goods and services, engineering training has been found to be a good prerequisite for management, law, and even medicine. It is much easier to teach marketing and management skills to an engineer than it is to teach engineering to business graduates (Engineering Manpower Commission 1991b). The United States is following a pattern established in Japan. That is, individuals with engineering backgrounds are entering management and finance in greater numbers than in the past (Engineering Manpower Commission 1990).

Figure 3-8.
Number of employed wage and salary workers who usually work full time



See appendix table 3-7. *Science & Engineering Indicators – 1993*

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*Even the top engineering schools reported significant reductions in the number of job offers received by their students. For example, Stanford University graduates were used to receiving five to seven job offers each; that number is now down to one or two (*Wall Street Journal* 1993). Also, many university placement directors are reporting that more engineering bachelors degree graduates were planning to attend graduate school. But many of these recent graduates were not continuing their education in engineering. For example, at the Massachusetts Institute of Technology, the number of engineering graduates applying to medical school rose nearly 40 percent between 1991 and 1992. See Engineering Manpower Commission (1992b).

**A small decline in students seeking engineering careers did occur during the 1970-72 "aerospace recession." See Engineering Manpower Commission (1991c).

recipients.[10] Although all recent college graduates have been affected by the decrease in recruiting activity, S&E graduates are faring better than those who majored in other disciplines (College Placement Council 1991).

In-Field Employment

The percentage of scientists and engineers who remain in S&E occupations (as opposed to the number who leave science and engineering to pursue careers in other fields). yields important information about the career paths of individuals trained in S&E fields and the supply and demand for their services. Data on S&E employment of recent college graduates show the proportion of recent S&E bachelors degree candidates working in S&E related jobs within 2 years following graduation increasing from 53 percent in 1980 to 58 percent in 1990 (SRS 1982 and 1992a). This trend is one of several indicators that a lot of S&E job creation occurred during the 1980s.

S&E employment rates vary widely by field. Recent (1988 and 1989) graduates with bachelors degrees in the social sciences and psychology had relatively low S&E employment rates—26 percent and 27 percent, respectively—in 1990. In contrast, recent graduates who majored in the computer, environmental, or physical sciences had much higher rates of S&E employment—85 percent, 77 percent, and 68 percent, respectively. These rates are comparable to those for the engineering specialties. In 1990, S&E employment rates exceeded 80 percent in all but one of the engineering disciplines.

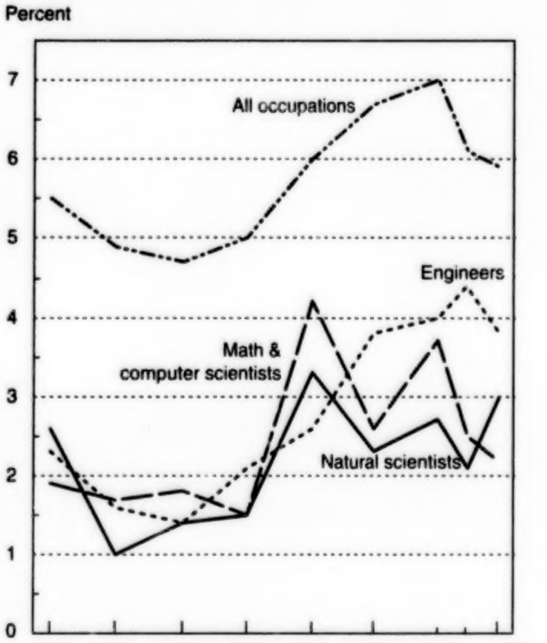
In-field employment rates—i.e., the proportion of graduates employed in the fields in which they got their degrees—are much lower than S&E employment rates. (See text table 3-1.) Not surprisingly, masters degree recipients are far more likely than those with only bachelors degrees to be employed in the fields in which they got their education. About 60 percent of all recent (1988 and 1989) masters degree recipients—compared to 38 percent of all recent bachelors degree recipients—were employed in their major fields of study in 1990.

College graduates who do not seek immediate employment usually enter graduate school. Approximately 20 percent of 1988 and 1989 S&E bachelors degree recipients were attending graduate school full time in 1990, down from 23 percent 10 years earlier (another indicator of healthy S&E job creation during the 1980s). Interestingly, over one-third of the 1988 and 1989 S&E bachelors degree recipients attending graduate school full time in 1990 were pursuing professional degrees in medicine, dentistry, law, or business.[11]

Attachment Rates

Little information is available on attachment rates of U.S. scientists and engineers. Rough estimates show that in the mid-1980s, fewer than half of those with degrees (at all levels) in engineering, and fewer than one-quarter of those with degrees in the natural sciences were employed in S&E occupations (Citro and Kalton 1989, p. 50). The rate was below 10 percent for social science majors. For those with masters or higher degrees in either the natural or social sciences, S&E employment rates were considerably higher—over one-third and nearly one-quarter, respectively. (There is relatively little difference in the S&E employment rates of engineers with

Figure 3-9.
Science and engineering unemployment rates, by occupation



See appendix table 3-11. *Science & Engineering Indicators – 1993*

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[10] The downturn in corporate recruiting on college campuses has been tracked and documented by Patrick Sheetz in Michigan State University's *Recruiting Trends* series, by Victor Lindquist in Northwestern University's *Lindquist Endicott Report*, by the College Placement Council, and by Valerie Law who maintains the Job Opportunity Barometer for *Graduating Engineer*. College Placement Council data show the number of corporate recruiters visiting each college campus dropping from an average of 42 in 1986 to 23 in 1993. The Job Opportunity Barometer published in March 1992 showed engineering recruitment down 22 percent from March 1991 to March 1992. The American Chemical Society in its 1993 employment outlook reports that "the job outlook for newly graduated chemists and chemical engineers remains gloomy." (According to the American Chemical Society, however, there is one "bright spot"—demand for chemical professionals by drug and consumer product companies remains strong.) Anecdotal information has also appeared frequently in the science press. For example, the June 8, 1992, issue of the *Scientist* contains a report on the dropoff in job offers at Caltech for students who specialized in aeronautics, computer science, physics, and mechanical engineering.

[11] Unpublished tabulations from NSF's 1990 Survey of Natural and Social Science and Engineering Graduates show that one-third of the 1988 and 1989 bachelors degree recipients who majored in the physical or life sciences and were in graduate school full time in 1990 were in medical school; 45 percent of the graduate students who majored in the social sciences were in law school.

Text table 3–1.
S&E and in-field employment rates of 1988 and 1989 S&E graduates, by degree field: 1990

Degree field	S&E occupation: Bachelors	S&E occupation: Masters	Employed in field: Bachelors	Employed in field: Masters
	Percent			
Total science and engineering	57.6	82.2	37.8	59.0
Sciences	47.6	77.1	33.2	59.6
Physical sciences	67.9	86.3	35.6	43.4
Mathematical sciences/statistics	66.2	83.3	39.6	57.4
Computer sciences	85.3	89.2	81.5	77.2
Environmental sciences	76.6	92.5	56.1	69.4
Life sciences	54.3	76.1	38.4	59.0
Psychology	27.2	57.8	9.9	48.1
Social sciences	26.0	55.2	14.1	43.5
Engineering	86.1	92.0	50.7	57.8
Aeronautical/astronautical	77.6	85.7	48.9	*
Chemical	88.5	100.0	49.6	*
Civil	89.4	95.2	71.1	69.1
Electrical/electronic	88.1	94.3	53.3	57.7
Industrial	80.0	72.7	42.2	26.5
Materials	84.6	100.0	*	*
Mechanical	88.7	94.1	44.3	60.4
Petroleum	100.0	100.0	*	*

NOTES: * = no rate was computed for groups with fewer than 1,500 individuals in labor force; S&E = science and engineering.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Recent Science and Engineering Graduates: 1990* (Washington, DC: NSF).

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bachelors or masters degrees.) At the doctoral level, S&E employment rates reach and exceed 90 percent; only those with doctorates in the social sciences have S&E employment rates dipping much below 90 percent. (See text table 3-2.)

S&E Salaries

Examining trends in salaries paid to workers is an important way of assessing the demand for labor, because rising relative wages usually indicate a scarcity of available workers.[12]

In general, scientists and engineers earn considerably more than most workers, and engineers earn more than scientists. In fact, engineering compensation is better than in most professions: Only lawyers, physicians, and pharmacists make more than engineers. (See appendix table 3-12, figure 3-10,

Text table 3–2.
Employment of scientists, engineers, and technicians: 1990 and projected for 2005

Occupation	Total employment: 1990	2005: Low	2005: Moderate	2005: High	Change 1990–2005: Low	Change 1990–2005: Moderate	Change 1990–2005: High
	Thousands				Percent		
Total, all occupations	122,573	136,806	147,191	154,543	11.6	20.1	26.1
All scientists, engineers, and technicians	5,650	6,177	7,606	8,964	9.3	34.6	58.7
Engineering, math, & natural science managers	315	337	423	505	6.8	34.2	60.0
Engineers	1,519	1,489	1,919	2,332	(2.0)	26.3	53.5
Life scientists	174	194	230	264	12.0	32.3	52.4
Computer, math, & operations research analysts	571	835	987	1,127	46.2	72.8	97.3
Physical scientists	200	187	241	294	(6.4)	20.5	47.6
Social scientists	224	296	320	342	32.3	42.8	52.6
Eng./science technicians & computer programmers	2,647	2,839	3,486	4,099	7.2	31.7	54.9

NOTE: Assumptions concerning the impact of defense downsizing on employment were included in the three scenarios.

SOURCE: Bureau of Labor Statistics, *Monthly Labor Review*, November 1991 and February 1992 (Washington, DC).

Science & Engineering Indicators – 1993

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[12] A good example of this occurred in the 1980s when the United States first began to experience an acute shortage of nurses. Nurses' salaries have been increasing faster than those for almost all other professional occupations.

Engineering Salaries

Since 1987, engineering salaries have barely kept pace with inflation, an indication that although there are or may have been some shortages in some engineering disciplines, they were not severe enough to cause a constant-dollar increase in the price of engineering services. "The sluggish growth in salaries [can be] attributed to a large pool of available engineering talent, defense budget cuts, and downsizing in industry, which increased the number of engineers in the job market" (Engineering Manpower Commission 1992a).

According to BLS data, the median annual salary for all engineers was $44,820 in 1992. Two other organizations, the Engineering Workforce Commission and the National Society of Professional Engineers, peg the 1992 median at $52,150 and $58,240, respectively.

Approximately 1.3 million engineers work for industrial firms. According to data from the Engineering Workforce Commission, the median annual salary of all engineers working in industry was $54,900. (See appendix table 3-8.) These data also reveal the following.

- Pay is somewhat higher in nonmanufacturing than manufacturing industries—$56,150 versus $53,850.
- Engineers working in the petroleum refining industry have the highest median annual salary among manufacturing industries; it was $72,500 in 1992. Those working in the chemicals, drugs, and plastics industry reported the second highest median annual salary—$65,400. Among all manufacturing industries, engineering salaries in these two industries exhibited about the largest percentage increases—27 to 28 percent—between 1987 and 1992.
- Among nonmanufacturing industries, research and development organizations paid engineers the highest median annual salary—$63,500—in 1992.
- The median annual salary received by engineers (both supervisors and nonsupervisors) at the bachelors degree level rose 19 percent—from $44,150 to $52,550—between 1987 and 1992. (See appendix table 3-9.) Engineers at the masters degree level saw their median annual salary increase only 14 percent—from $51,950 to $59,350. Doctoral salaries rose 18 percent—from $59,700 to $70,600. (Only about 4 percent of the engineers working in industry have doctoral degrees. See Engineering Manpower Commission 1992a.)
- In 1992, nonsupervisory engineers with masters degrees made an average of about $6,000 more per year than engineers at the bachelors degree level. The Ph.D. premium—the salary differential between those engineers holding doctorates and those with masters degrees—was about $10,000.
- Engineers with supervisory responsibilities make an average of about $20,000 more per year than those without supervisory responsibilities.
- The starting pay of recent engineering graduates has been increasing at a faster pace than the median salary paid to experienced workers. This "compression" or narrowing of the range of compensation between younger and older engineers indicates that the relative value of experience in the workplace has been declining (Engineering Manpower Commission 1992a).

and "Engineering Salaries.")

Besides being lower than the salaries of doctors and lawyers, scientists' and engineers' salaries have been increasing at a slower pace. Between 1987 and 1992, the median salaries of natural scientists and engineers increased about 20 percent. Salaries for mathematical and computer scientists increased somewhat faster (28 percent). These gains, however, did not match those for other occupations that require training beyond undergraduate school. Physicians' median annual salaries rose 44 percent and lawyers' increased 33 percent during the same time period.[13]

Beginning Salary Offers

Despite the tight labor market, most recent S&E graduates continue to command increasingly higher starting salaries than they did a few years earlier. The rate of increase, however, appears to have slackened after 1990.

Among all bachelors degree candidates, chemical and petroleum engineering majors received the highest starting salary offers, averaging $39,500 and $38,400, respectively, in 1993. (See appendix table 3-13.) Average starting salary offers in these two fields also exhibited large average annual percentage increases—5.0 and 3.7 percent, respectively, between 1988 and 1993. These gains were higher than those registered by any other field—except nursing, which had a 5.6-percent average annual increase during the same period.

Recent engineering, computer science, physics, mathematics, and chemistry bachelors degree recipients receive higher salary offers than graduates in almost every other field. In 1993, starting salary offers exceeded $30,000 in all engineering disciplines (except civil engineering) and in computer science. (Nursing was the only other major with a starting salary above $30,000.) Chemistry, physics, and mathematics were close behind

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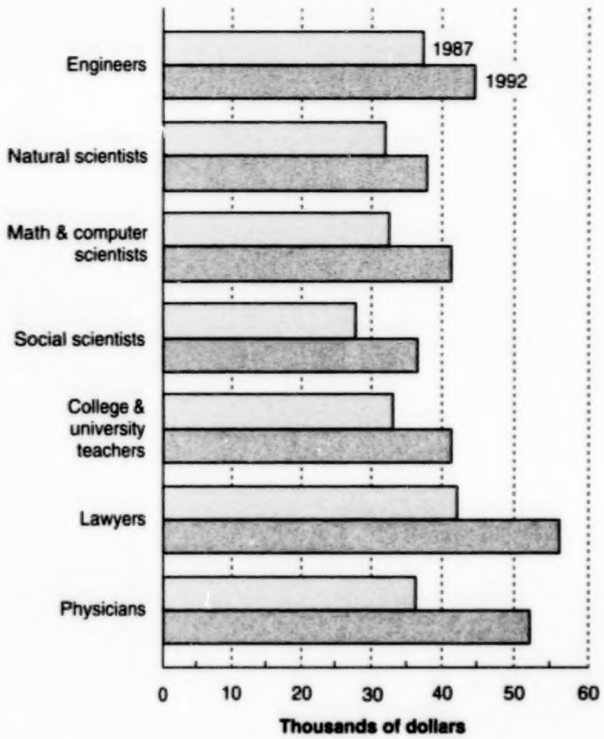
[13] Two other occupations—psychology and registered nursing—also registered large (37 to 38 percent) median annual salary increases between 1987 and 1992.

Figure 3-10.
Median annual salaries of full-time workers



See apendix table 3-12. *Science & Engineering Indicators – 1993*

with average starting salary offers of $28,000, $26,800, and $26,500, respectively. The beginning salary offers received by recent undergraduate degree recipients who majored in the biological sciences, psychology, and sociology were considerably lower. In 1993, the figures for these majors were between $20,000 and $23,000.

In general, the rate of increase in starting salary offers slowed after 1990. For example, between 1990 and 1993, beginning salary offers in aerospace/aeronautical engineering increased at an average annual rate of 1.2 percent, far below the 4.1-percent rate registered between 1988 and 1990. Similarly, the average annual rate of increase for civil engineering majors fell from 4.8 percent between 1988 and 1990 to 1.3 percent between 1990 and 1993. In addition, students who majored in the biological sciences, mathematics, physics, and psychology received on average lower salary offers in 1993 than their counterparts received in 1990.

Forecasting the S&E Job Market

Forecasting supply and demand for scientists and engineers is an extremely difficult (see Vetter 1992a and 1993 and Fechter 1990), and rarely accurate (see Leslie and Oaxaca 1990), undertaking. For example, how could anyone have predicted the end of the Cold War and its aftermath? Although the end of the Cold War has not caused a major disruption in U.S. labor markets for scientists and engineers, some turmoil is being generated by newly jobless engineers (many of whom have spent their entire careers in the U.S. defense industry) and by scientists exiting the former Soviet Union.

BLS analysts have conducted several studies of the future job market for scientists, engineers, and technicians. Findings from these studies yielded the following conclusions:

- Employment in technical occupations will grow at a faster pace than overall employment.
- Employment in technology-intensive industries will grow at about the same rate as employment in general.
- Surpluses are more likely to be observed in the S&E job market than shortages, but the latter (especially in specific fields) cannot be ruled out.

Every 2 years, BLS analysts prepare employment projections by occupation and by industry for the entire economy. The most recent forecast was prepared in 1991 and covered the period 1990-2005. Data derived for technical occupations are presented in text table 3-2. They show wide variations in employment growth under the three alternative scenarios—which prescribe high, moderate, or low growth for the economy—BLS uses for projecting future employment. (Assumptions concerning the impact of defense downsizing on employment were included in these scenarios.) For all technical occupations, growth over the 1990-2005 period is projected to range from 9 percent (using the low-growth scenario) to 59 percent (in a high-growth economy). The moderate-growth alternative yields a 35-percent increase, a much higher gain than the 20-percent increase in employment projected for the economy as a whole (Silvestri and Lukasiewicz 1991).

Among individual scientific and technical occupations, projections for engineering employment show the widest variation: from a 2-percent decline (using low-growth assumptions) to a 54-percent increase (under the high-growth scenario). Engineering employment is more sensitive to changes in the economy and the defense budget than employment in the other technical occupations. Under each of the three alternatives, computer, mathematical, and operations research analysts are expected to have the highest growth rates, ranging from a 46- to a 97-percent increase. Employment of social scientists shows the least variation in growth—up or down 7 percent—depending on the state of the economy.

As part of this ongoing effort, the National Science Foundation (NSF) sponsored a special BLS study of employment growth in approximately 50 industries that employ the highest concentrations of technical personnel and all levels of government (Braddock 1992).[14] Once again, projections were based on three alternative scenar-

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[14] Braddock's definition of high-tech industries differs from the Organisation for Economic Co-operation and Development definition used in chapter 6.

Text table 3–3.
Unemployment, underemployment, and S&E employment rates of doctoral scientists and engineers, by degree field: 1991

Degree field	Un-employment	Under-employment	Employment in S&E
	Percent		
Total science and engineering	1.4	1.7	89.7
Sciences	1.5	1.8	89.0
Physical sciences	2.0	1.0	91.9
Mathematics	0.3	0.8	92.4
Computer sciences	1.4	0.3	95.3
Environmental sciences	1.1	1.9	94.1
Life sciences	1.7	1.6	92.6
Psychology	1.2	1.0	90.3
Social sciences	1.4	3.5	75.7
Engineering	1.1	0.9	93.4
Aeronautical/astronautical	1.6	1.2	96.2
Chemical	1.0	0.9	93.2
Civil	0.5	0.3	94.8
Electrical/electronic	1.7	1.1	95.2
Materials	0.9	0.4	93.2
Mechanical	1.1	1.1	92.7
Nuclear	1.2	1.8	92.4
Systems design	0.8	1.2	88.2
Other engineering	0.8	1.0	91.1

NOTES: Underemployed doctoral scientists and engineers are those who reported that they were either (1) holding part-time positions when they would have preferred working full time, or (2) working in non-S&E occupations when they would have preferred S&E jobs.

S&E = science and engineering.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers: 1991* (Washington, DC: NSF, forthcoming).

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ios. In addition to the economic and other assumptions used in the original BLS model, additional variables that affect employment in high-tech industries—e.g., the propensity for the Nation to spend money on R&D and the export of products with a high technology content—were incorporated in this model.

The results of the analysis show employment in technology-intensive industries increasing about 20 percent (in the mid-range scenario) between 1990 and 2005: This is about the same as the employment growth rate forecast for the economy as a whole. This finding is counter to projections made a few years earlier (BLS 1990) that showed employment in high-tech industries increasing at a faster pace than overall U.S. employment. The change is largely attributable to the turnaround in defense spending that occurred in the late 1980s. The curtailment of military-related expenditures is lowering the rate of employment growth in technology-intensive industries, bringing the rate of increase down to the level expected for all U.S. employment.

These two BLS studies present an interesting anomaly: Although employment in technical occupations is expected to increase faster than overall employment, employment in technology-intensive industries is not expected to increase any faster than employment in nontechnology-intensive industries. One explanation is that in the less technology-intensive industries—e.g., those in the service sector—the proportion of the workforce comprised of scientists and engineers is increasing faster than employment in general.

The BLS analysis of the job market for technical workers was carried another step farther in an attempt to determine whether the supply of new S&E graduates would be sufficient to fill the new jobs created in the near future (1990-2005) and to replace workers who retire or leave S&E jobs. Once again, three estimates of the supply of new S&E graduates were prepared; they were calculated using (high, moderate, and low) percentages of the college-age population expected to earn bachelors degrees in science and engineering.[15]

Next, the number of new S&E graduates derived under each of the three supply scenarios was compared with the number of job openings derived from each of the three employment growth scenarios for all technical occupations. Matching the three supply with the three demand estimates yielded nine possible depictions of the future job market for technical workers. Each of these nine alternatives was then compared with a benchmark determined by BLS staff to be the ratio of technical degrees awarded annually to the number of technical job openings during a time (1984-90) when the supply of new S&E graduates was thought to be equal to the demand for them. In the late 1980s, the ratio of technical degrees awarded annually to the number of technical job openings was about 1.6. That is, of every 16 S&E graduates, 10 took S&E jobs; the other 6 either went into non-S&E occupations or left the country.

Using this 1.6 ratio as the benchmark, it was determined that most of the nine supply-demand possibilities yielded ratios equal to or higher than 1.6—that is, the supply of S&E graduates was greater than the demand. Only in three of the alternatives—those in which high-growth estimates were coupled with low-growth estimates of technical degree production—would there be situations in which shortages might exist. The results of this modeling exercise indicate that although there may be future shortages of technical workers in some fields, overall, there are more likely to be surpluses in the coming decade and beyond.[16]

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[15] This method of estimating the supply of new scientists and engineers has several deficiencies cited by Braddock (1992), the most important of which is the omission of other sources of supply, i.e., (1) individuals switching to S&E jobs from other occupations and (2) immigrants.

[16] In a response to the BLS findings, Finn and Baker (1993) show that there are likely to be more shortage situations than predicted using BLS' model. They reach this conclusion by showing that the BLS estimates of degree production are overly optimistic.

Employment of Doctoral Scientists and Engineers

Employment by Sector

In 1991, approximately 367,400 doctoral scientists and 69,800 doctoral engineers were employed in the United States. (See appendix table 3-14.) About half the scientists were employed at educational institutions; nearly one-third were employed by industry. (See figure 3-11.) During the past two decades, employment of doctoral scientists has been shifting from the academic to the industrial sector.[17] A similar trend occurred among doctorate-holding engineers. The proportion of these engineers employed at colleges and universities declined during the late 1970s and 1980s; concurrently, the share employed in industry increased (NSB 1991). In 1991, one-third of employed doctoral engineers worked at academic institutions; a much higher proportion—57 percent—worked in industry.

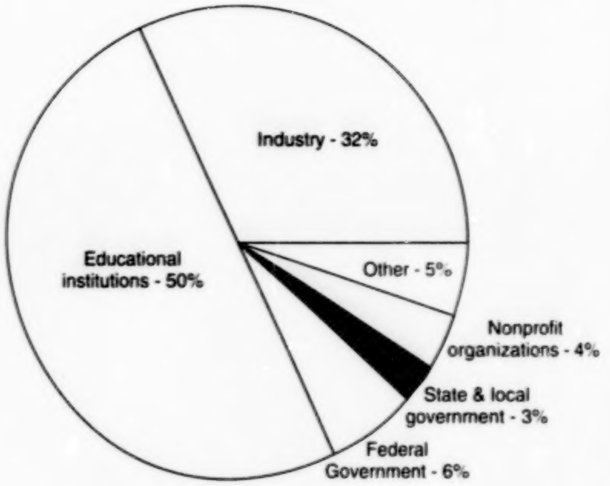
Unemployment and Underemployment

Doctorate-holding scientists and engineers have an extremely low unemployment rate. The 1991 unemployment rate for all these scientists and engineers was 1.4 percent—far below the overall U.S. unemployment rate of 6 percent. In only two fields—chemistry (2.3 percent) and sociology/anthropology (2.9 percent)—did doctoral scientists have unemployment rates exceeding 2 percent.

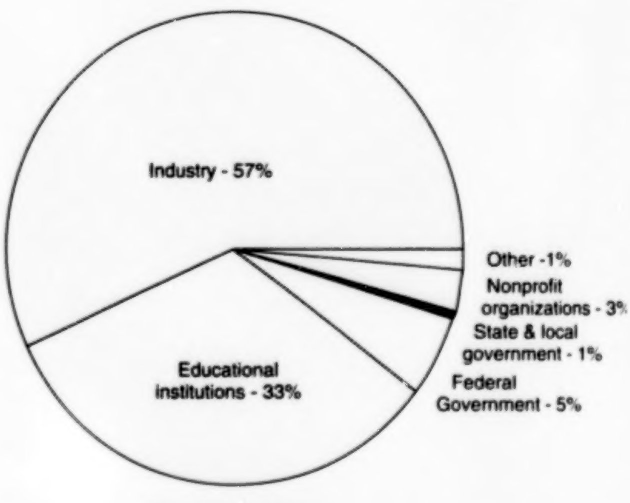
Underemployment of doctoral scientists and engineers is also rare. In 1991, only 1.7 percent of doctorate-holding scientists and engineers in the workforce were either (1) holding part-time positions when they would have preferred working full time, or (2) working in non-S&E occupations when they would have preferred S&E jobs. However, underemployment in the social sciences was relatively high—3.5 percent; it was even higher in the social science subfield of sociology/anthropology.

Despite these numbers, several professional associations[18] have been documenting employment difficulties faced by new Ph.D. recipients, focusing on one issue in particular—the lack of permanent, full-time positions in academia. According to these groups, competition among new Ph.D. recipients for each tenure-track opening is fierce; many new doctorate-holders are becoming increasingly discouraged after long, unsuccessful job searches.[19]

Figure 3-11.
Employed doctoral scientists and engineers, by sector: 1991



Doctoral scientists
N = 367,440



Doctoral engineers
N = 69,766

See appendix table 3-14. *Science & Engineering Indicators – 1993*

The apparent oversupply of doctoral scientists in some fields is being blamed on

- perceived cutbacks in basic research funding.
- growth of "big science" projects (Flam 1992).

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[17] Unpublished tabulations from the American Institute of Physics' 1989 Society Membership Sample Survey show that fewer than a quarter of the physicists who received their doctorates before 1969 work in industry. In contrast, over 40 percent of those who received their degrees between 1987 and 1989 are employed in industry. The comparable proportions for university employment were 47 percent and 28 percent, respectively. (These data do not include postdoctoral scientists.)

[18] The most vocal of these professional associations is a relatively new organization called the Young Scientists Network. Others voicing similar concerns are the American Institute of Physics, the American Mathematical Society, and the American Chemical Society. Surveys of the latter society's membership show unemployment among new doctoral chemists (which did not rise above 4 percent during the recession years in the early 1980s), increasing sharply in recent years. American Mathematical Society data show the unemployment rate of new mathematics doctorate recipients, which is normally about 2 percent, at an all-time high of 5 percent in 1992. See McClure (1992).

[19] According to the American Mathematical Society (AMS), new faculty recruitment in mathematics departments is down dramatically. AMS documented that there were 17 percent fewer full-time positions in doctorate-granting mathematics departments in 1990/91 than in the preceding year; positions in masters- and bachelors-granting institutions were also down sharply, 34 percent and 18 percent, respectively. See McClure (1992).

Text table 3–4.
Average annual salary offers to doctoral degree candidates in selected fields: 1988–93

	Salary			Change from previous year		
	Chemistry	Math	Physics	Chemistry	Math	Physics
				Percent		
1988	41,292	40,668	42,480			
1989	43,147	45,438	42,263	4.5	11.7	*
1990	45,356	42,775	41,486	5.1	*	*
1991	47,911	41,146	39,913	5.6	*	*
1992	50,719	40,954	40,940	5.9	*	*
1993	50,933	39,500	50,600	0.4	*	*

NOTES: Data are as of September of each year. * = not computed for fewer than 20 offers.

SOURCE: College Placement Council, Survey of Beginning Salary Offers, annual series.

Science & Engineering Indicators – 1993

- the exodus of scientists from the former Soviet Union and Eastern Bloc countries (an already overcrowded job market is being flooded by these new arrivals).[20]
- tight state budgets that have resulted in cutbacks and hiring freezes at state-supported institutions (Brennan, Rawls, and Zurer 1992; and Cipra 1991).

Some doctoral scientists unable to find academic posts are reluctantly taking second and third postdoctoral research positions.[21] The most recent NSF data (which cover years through 1991), however, do not show a sizeable increase in the number of postdoctorate appointments (SRS 1992c).

Although scientists have been vocal in their complaints about the lack of jobs, few data are currently available to support their contentions. The most recent comprehensive, statistically valid doctoral employment data are for 1991; 1993 data are not yet available. There is a smattering of data collected by professional associations that points to a tightening of the Ph.D. job market in the 1990s. For example, data collected by the American Institute of Physics show the proportion of employed doctoral recipients who took more than 6 months to secure permanent positions increasing from 13 percent in 1989 to 22 percent in 1991. (Additional numbers provided by professional associations on the worsening job market faced by their members appear in some of the footnotes in this section.) Also, data on beginning salary offers to doctoral degree candidates may indicate a plentiful supply of applicants for available jobs. Average annual salary offers in mathematics and physics fell between 1989 and 1991. (See text table 3-4.) Although beginning salary offers for physicists appear to have increased after 1991, those received by mathematicians continued to fall, and those received by chemists did not increase appreciably between 1992 and 1993.

From another perspective, labor market experts, and even fellow members of the S&E community, have been contending that there is no shortage of challenging work opportunities for doctoral scientists.[22] Most of those opportunities are in industry and some will be in nonscientific specialties, "where science or engineering training is not only invaluable but also a growing concomitant of management success and industrial and governmental leadership so necessary in this technological age" (White 1991).

In the past, there was considerable resistance among new doctoral scientists to employment in the industrial sector.[23] Many in the academic community held the belief that the most important work—basic research—was done in a university setting, and that only university laboratories could offer the academic freedom necessary to explore new ideas. But the stereotype of industry as a place where only second-rate research is conducted has been fading because:

- The academic world has become more constrained. The quest for funding has become a never-ending mission. Because funding is so difficult to secure, scientists may not be able to follow their own research agenda; instead, they may be limited to conducting research in areas of interest to those organizations willing to provide the funding (Barinaga 1992). (See chapter 5 for a discussion of the academic R&D sector.)

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[20] For example, as many as 300 mathematicians from the former Soviet Union have sought employment in the United States in the last 2 years. According to data collected by the American Mathematical Society, the ratio of applicants to positions in the AMS register made a more than 180 degree turnaround—from 1:2 in the mid-1980s to nearly 3:1 in 1992. Immigrants accounted for 13 percent of new Ph.D. recipients hired by doctorate-granting departments. See McClure (1992).

[21] The American Chemical Society's survey of its membership revealed that the proportion of new chemistry Ph.D. recipients taking postdoctorate positions increased from 34 percent in 1990 to 37 percent in 1991 to 45 percent in 1992.

[22] Some physicists have found rewarding work in software engineering, patent law, health physics, accounting, and many other fields. And mathematicians are finding opportunities in the insurance and banking industries and even in the environmental field where "modeling should provide substantial opportunity for applied mathematicians for years to come" (Seitelman 1991). Alan Chynoweth, head of research at Bellcore, told a *Science* reporter (Flam 1992) that " there's no shortage of really interesting work to be done if people are willing to be flexible." Most physicists do find work in physics, although the jobs they get may not have been their first choice.

[23] In addition, many new doctoral physicists and chemists are unprepared for jobs in industry, having "never set foot in an industrial laboratory (let alone a factory)" (Weatherall 1992).

- The growing number of successful industry-university collaborations (see chapter 4) has helped erase the anti-industry stigma (Holden 1991).

Salaries

Industry has always been more attractive than academia in one important respect—salary. In all but one scientific field, doctoral salaries are higher in industry than in academia.[24] (See appendix table 3-15.) In the 1980s, however, faculty salaries rose at a faster pace than those paid scientists working in industry, narrowing the gap between the two pay levels (Finn 1991, p. 27).

The median salaries for both doctoral engineers and doctoral scientists working in *industry* were roughly comparable—$71,400 for engineers, and $69,000 for scientists, in 1991.[25] In the *academic* sector, however, there is a striking divergence between the two medians. The median annual salary of all doctoral engineers employed at academic institutions—$67,800—is significantly higher than the median salary for all scientists—$55,200. This $13,000-difference reflects the fact that in recent years many universities had difficulty recruiting engineering faculty and therefore had to offer salaries competitive with those offered by industry. Only 6 to 7 percent of all engineers have doctoral degrees, making them a scarce commodity—one much in demand at engineering-intensive research organizations like NASA, as well as on college campuses (Engineering Manpower Commission 1992b).

Although the median salary for all doctoral engineers is higher in industry than in academia, that is not the case in three engineering specialties—civil, materials science, and nuclear.

Although faculty positions in several fields are currently scarce, demand for college and university professors is expected to increase in the late 1990s and continue to increase beyond the year 2000 because

- college enrollment will be rising (a turnaround from the current decline) as the offspring of the baby boom generation reach college age;
- college professors hired in the 1950s and 1960s will be retiring, creating an unusually large number of vacancies in academia and the need to replace them;[26]
- the annual number of U.S. citizens obtaining doctorates in science has not risen appreciably for the past two decades, and there are no indications it will increase in the foreseeable future (SRS 1993b).

Special Populations in the S&E Workforce

Employers have begun to recognize the value in having a diversified workforce, one in which women and minorities are represented in proportions that approach their representation in the total population. They are also aware that the majority of new workforce entrants are women and minorities. Therefore, they are making it a priority to hire more women and minorities to fill white-collar vacancies in their organizations. Meeting their goals for hiring women and minorities has generally proven difficult, however,[27] especially in particular occupations. A common complaint among technical recruiters is an inability to find sufficient numbers of women and minorities to fill S&E positions in their companies. While women and minorities have made great strides in attending college and moving into other professions once dominated almost entirely by white men, e.g., medicine, law, and business, their participation rates in engineering and some of the physical sciences still lag far behind those of white males (SRS 1992d). Moreover, S&E pipeline statistics (see chapters 1 and 2) indicate that the number of female and minority physical scientists and engineers will not be much larger in the foreseeable future.

Women

Thirty years ago women had few career choices. Although the number of women acquiring college degrees increased steadily during the 1950s and 1960s, women's employment opportunities were largely limited to teaching or nursing. Today, women have an unlimited number of career options.[28] Disproportionately few, however, choose engineering; women are also underrepresented in some of the physical science fields, e.g., physics and geology. (See "Factors in Female Underrepresentation" for information on current research into the reasons for women's underrepresentation in these fields.)

In 1992, just 9 percent of U.S. engineering jobs were filled by women. In addition, only 13 percent of working physicists and astronomers, and 11 percent of geologists, were female. (See figure 3-12.) In contrast, in 1992, nearly one-third of all lawyers and over one-quarter of all physicians in the labor force were women.[29] Also, women

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[24] It is often noted that the difference between Ph.D. median salaries in industry and in academia is actually smaller than the data indicate. That is because many academically employed scientists and engineers have 9- or 10-month contracts; they earn additional income (not included in the data presented in this chapter) from consulting and teaching during the summer.

[25] Data collected by the Engineering Workforce Commission show the 1992 median salary for doctoral engineers working in industry to be $70,600. (See appendix table 3-9.)

[26] For example, in chemistry departments the number of retiring professors is expected to increase from 250 per year in 1990 to 350 per year by 1995 and then to 450 per year in 2000 (Brennan, Rawls, and Zurer 1992).

[27] Dupont has been one of the most successful companies in recruiting women and minorities. Dupont's goal—that at least 40 percent of its new (professional and technical) hires should be women and minorities—has been exceeded in most years. The company has even been successful in recruiting enough women and minorities to meet its 40-percent target in filling S&E jobs (McCormick 1992).

[28] Turner and Bowen (1990), in a study of college degrees awarded to women, concluded that women now attending college who once could have been expected to major in teaching, now choose instead to major in business.

[29] These percentages will climb steadily for at least several more years because women now comprise about 40 percent of the students currently attending medical school and half of those in law school.

Factors in Female Underrepresentation

The literature is replete with accounts of comprehensive analyses as to why women are underrepresented in engineering and some of the physical sciences. Most of the research points to differences in the education* and socialization of women, and the lack of female scientists and engineers as role models as the primary reasons women have made so little progress in these professions.

Unquestionably, these are all important factors. But they do not explain the remarkable progress women have made in knocking down the barriers to entry in other challenging professions. The best example is the field of medicine. Women have demonstrated their ability to meet the rigorous educational and other requirements necessary to obtain medical degrees in numbers approaching those of men. For example, in 1992, 5,500 women earned medical degrees; in that same year, only 86 U.S. women were awarded doctorates in physics (SRS 1993b).

One of the reasons qualified women and men are choosing careers in medicine (and law and business) over those in science and engineering is obvious—salaries are higher. In addition, some researchers have been digging deeper, searching for other clues. Some of the most promising inquiries in this area appear to be those scrutinizing the image of science and engineering as portrayed in the media and other forms of popular culture (see Augustine 1991).

*For example, Vetter (1990) sees lack of preparation and proficiency in mathematics as the single most important barrier precluding women from engineering careers.

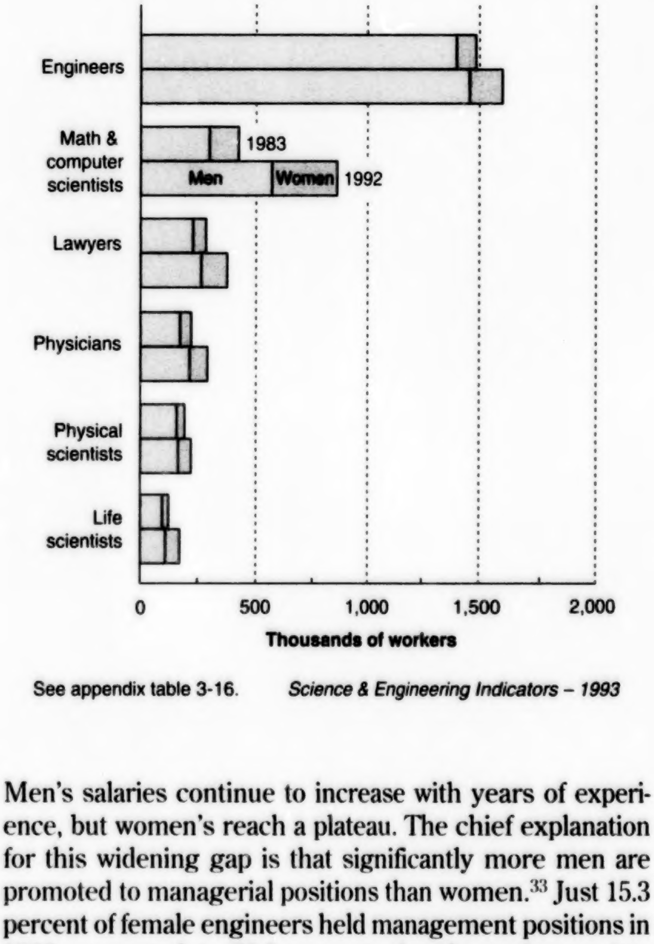
have made great gains in employment in many of the sciences. They now account for 40 percent of the biological scientists, 30 percent of the chemists, and nearly 60 percent of the psychologists. (See appendix table 3-16.)

Women in Engineering. Despite recent progress,[30] no profession exhibits a greater disparity in the employment of men and women than engineering. As recently as 1970, only 358 bachelors degrees in this field (fewer than 1 percent of the total) were awarded to females. Between 1975 and 1985, there was tremendous growth in the number of engineering baccalaureates granted to women, with the number of awards increasing from fewer than 900 in 1975 to more than 11,000 in 1985. Although the annual *number* of undergraduate engineering degrees awarded to women fell slightly in the 1990s, the *percentage* of degrees received by women is holding steady at about 16 percent.[31]

The scarcity of women obtaining engineering degrees is reflected in starting salary data: New female engineering graduates receive higher starting salaries than men. The average weighted starting salary offer for bachelors degree candidates in engineering was $34,485 for women, compared to $33,612 for men, in 1993.[32]

Higher starting salaries notwithstanding, a gap begins to appear after several years of experience are acquired. Men's salaries continue to increase with years of experience, but women's reach a plateau. The chief explanation for this widening gap is that significantly more men are promoted to managerial positions than women.[33] Just 15.3 percent of female engineers held management positions in 1986, compared to 35.5 percent of male engineers (SRS

Figure 3-12.
Employed wage and salary workers who usually work full time, by occupation and sex



See appendix table 3-16. *Science & Engineering Indicators – 1993*

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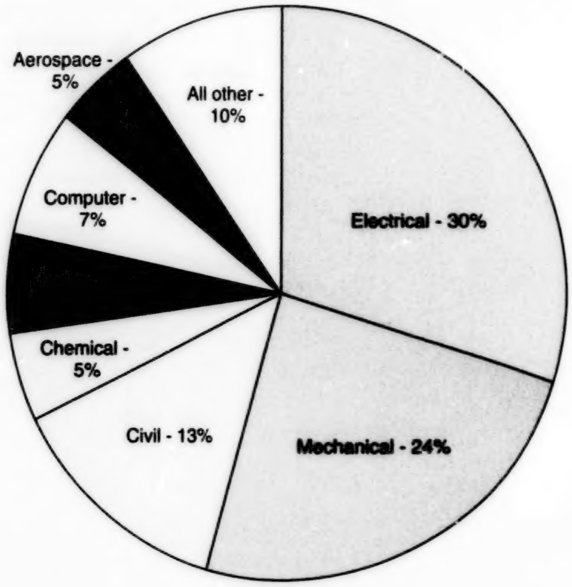
[30] Between 1983 (the earliest year for which comparable data are available) and 1992, the percentage of women engineers in the workforce increased from 5.9 percent to 8.7 percent.

[31] Engineering Workforce Commission (1993). Although the number of bachelors degrees in engineering awarded to women fell slightly in the 1990s, the number of graduate degrees has continued to rise. Overall, masters and doctorate awards in engineering increased 6.7 percent and 9.8 percent, respectively, from 1990 to 1992. Awards to women in these two categories, however, increased 15.4 percent and 19.6 percent, respectively, during the same period.

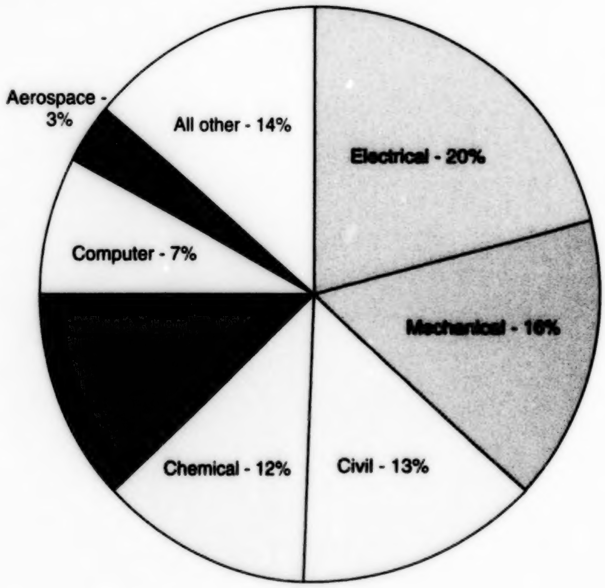
[32] Derived from the College Placement Council's 1993 Salary Survey.

[33] A number of recent studies have documented the underrepresentation of women in corporate management. See Brush (1991).

Figure 3-13.
Bachelors degrees in engineering, by sex: 1992



Men
n = 53,681



Women
n = 9,972

Source: Engineering Workforce Commission, "Women in Engineering," *Engineering Workforce Bulletin* No. 125, May 1993

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1990).[34] The difference in the percentages of men and women engineers in management is in large part attributable to the fact that female engineers are usually younger and less experienced than their male counterparts.[35]

Additionally, women and men are distributed differently among engineering specialties, as indicated by bachelors degree awards.[36] (See figure 3-13.) Electrical and mechanical engineering are chosen most often by both men and women. Women, however, are more likely to specialize in industrial and chemical engineering, while men are more likely to pick civil, computer, and aerospace engineering.

Women in Academia. Female scientists and engineers hold fewer tenured positions at universities than their male counterparts. In 1990/91, only 17 percent of the full-time female faculty in U.S. colleges were full professors, compared to 44 percent of the male professors (Brush 1991, p. 411, and Ehrenberg 1991). The numbers for the natural sciences and engineering are even lower. In 1989, there were 61,000 full professors in the natural sciences and engineering in the United States, of which only 3,800 were women (SRS 1992d).

Women comprised 18.8 percent of the doctoral S&E workforce in 1991. (See text table 3-5.) While women are well-represented in psychology and fairly well-represented in the social and life sciences, they accounted for only 3.4 percent of all doctoral engineers in 1991. Of all academic fields, engineering has the lowest proportion of women with Ph.D. degrees.

Minorities

Like women, members of the two largest minority groups in the United States—blacks and Hispanics—are underrepresented in the S&E workforce. In contrast, Asians—the third largest minority group—make up a larger share of the S&E workforce than their representation in the total population.

Blacks are underrepresented in many professional specialty occupations. Nowhere is this more evident than in science and engineering. (See appendix table 3-17.) Although blacks comprised about 11 percent of the total U.S. workforce and 8 percent of all those in professional specialty occupations in 1992, only 4 percent of employed engineers and 2.7 percent of the natural scientists were black. (See figure 3-14.) Their representation in mathematical and computer science occupations was somewhat higher at 7.1 percent. Although some progress has been made over the past decade—e.g., the proportion of black engineers in the workforce rose from 2.6 percent in 1983

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[34] American Chemical Society data also show that as male chemists acquire more experience, they are far more likely than females with similar years of experience to go into management. In addition, these data show that women have not made any progress in moving into R&D management positions. In 1990, 7 percent of female chemists in industry were R&D managers, the same percentage recorded 10 years earlier (Hileman and Rawls 1991).

[35] Also blamed for the dearth of female engineers in management are various socialization factors—e.g., women are less concerned with work, are not driven by a desire for high-status positions or promotions, and are only working until they raise a family (See Vetter 1992a).

[36] Women's particular choices in engineering provide support for the supposition that women are more likely than men to select S&E fields that have more bearing on the well-being of humans and their quality of life. Similarly, in the natural sciences, women are more highly represented in the life sciences than in the physical sciences (Baignee 1990, pp. 7-9).

Text table 3–5.
Female and minority proportions of doctoral science and engineering workforce, by degree field: 1991

	Proportion of science & engineering workforce				
	Female	Black	Asian	Native American	Hispanic
	Percent				
Total science and engineering	18.8	2.1	9.8	0.2	1.8
Sciences	21.7	2.2	7.3	0.2	1.8
Physical sciences	8.9	1.1	11.3	0.1	1.7
Mathematics	10.2	1.1	10.7	0.1	2.2
Computer sciences	11.8	0.5	20.3	0.1	1.7
Environmental sciences	9.6	0.2	5.3	0.2	1.0
Life sciences	24.0	1.9	7.8	0.2	1.6
Psychology	38.1	3.1	1.6	0.2	2.0
Social sciences	23.9	4.2	5.6	0.2	2.1
Engineering	3.4	1.2	23.1	0.2	1.9
Aeronautical/astronautical	2.0	1.4	19.3	*	1.5
Chemical	3.7	0.8	24.4	*	1.2
Civil	3.6	2.4	23.0	0.2	2.0
Electrical/electronic	2.5	1.3	23.3	0.1	1.9
Materials	6.0	0.9	25.2	0.2	3.0
Mechanical	2.1	1.4	26.7	0.1	2.0
Nuclear	2.8	0.3	18.8	*	2.8
Systems design	13.4	5.8	15.8	*	4.3
Other engineering	3.2	0.3	20.9	0.4	1.5

NOTE: * = no cases reported.

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers: 1991* (Washington, DC: NSF, forthcoming).

Science & Engineering Indicators – 1993

to 4 percent in 1992, and the percentage of mathematical and computer scientists increased from 5.2 to 7.1 percent—their representation among natural scientists actually declined, dropping from 3.1 percent to 2.7 percent during this period.

Employment of Hispanics in S&E occupations shows a similar degree of underrepresentation, one that is perhaps even more severe in the case of professional specialty occupations in general. However, Hispanic representation in all three S&E categories—engineering, mathematical and computer science, and natural science—increased between 1983 and 1992.

There are some positive trends. The production of minority engineering graduates has been increasing steadily. Data from the Engineering Workforce Commission show the percentage of bachelors degrees in engineering awarded to

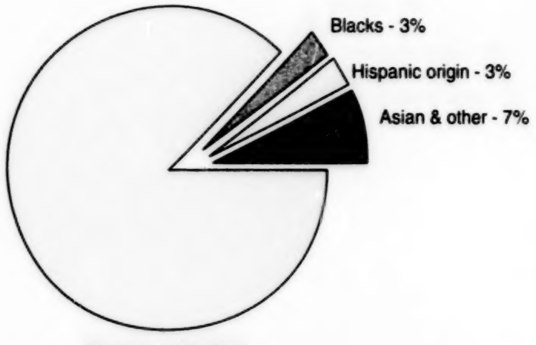
- blacks increasing from fewer than 1 percent in 1970 to nearly 4 percent in 1991, and
- Hispanic graduates (of domestic institutions) increasing from 1.8 percent in 1973 to 3.6 percent in 1991.

Doctoral statistics in engineering remain an area of concern. Unlike Hispanics, blacks have made almost no progress in the past decade toward increasing their representation among Ph.D.-holding natural scientists and engineers. Blacks earned only 1.3 percent of the doctorates awarded in the natural sciences and engineering in 1990; this was about the same percentage as their proportion in 1980. In contrast, the number of Hispanics earning doctoral degrees more than doubled. The proportion of all doctoral degrees awarded to Hispanics rose from just over 1 percent in 1980 to 2.7 percent in 1990.

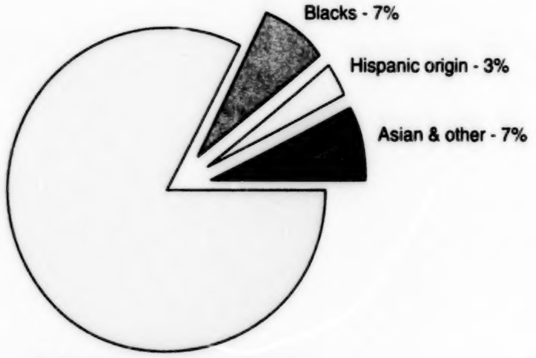
Doctoral workforce statistics are similar. Only 1.5 percent of the doctorate-holding natural scientists, and 1.2 percent of the doctoral engineers, working in the United States in 1991 were black. (See text table 3-5.) Hispanics accounted for slightly higher proportions—1.7 percent and 1.9 percent, respectively. In contrast, 9.8 percent of doctorate-holding natural scientists and 23 percent of doctorate-holding engineers working in the United States in 1991 were of Asian origin.

The scarcity of black and Hispanic scientists and engineers has made them a much sought-after group of potential employees. Despite the slowdown in recruiting activity in the 1990s, a recent survey revealed that employers consider diversifying their workforces and the availability of minority candidates in technical specialties to be among their major concerns (College Placement Council 1991). *Graduating Engineer*, a journal that monitors job prospects for minority engineering candidates, deter-

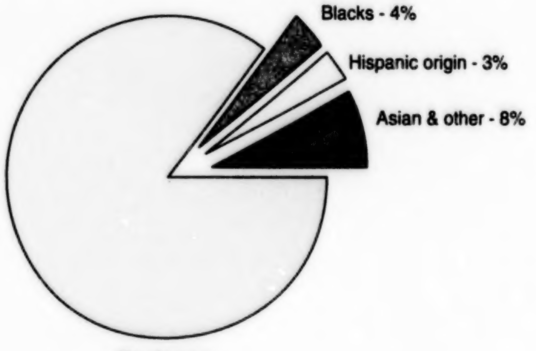
Figure 3-14.
Representation of minorities in the science and engineering labor force: 1992



Natural scientists
N = 402,000



Math and computer scientists
N = 861,000



Engineers
N = 1,594,000

See appendix table 3-17. *Science & Engineering Indicators – 1993*

mined that minority students have a slight, but definite, edge over their nonminority, male counterparts in competing for engineering jobs (Law 1992).

Immigrant Scientists and Engineers

Immigrant scientists and engineers have always been a crucial component of the S&E workforce in the United States. In 1992, nearly 23,000 scientists and engineers immigrated to the United States, 62 percent more than in 1991. The 1992 increase is probably due to enactment of the Immigration Act of 1990, which nearly tripled the number of employment-based visas that can be issued annually.

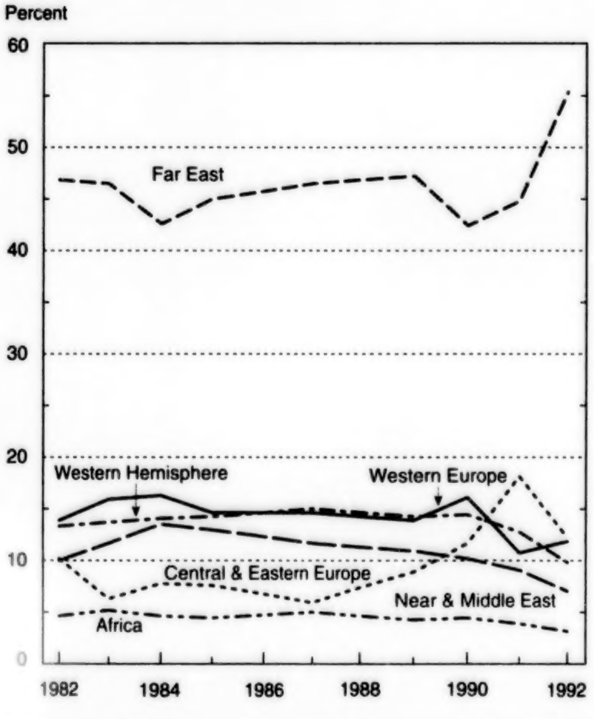
Regions of Origin. Most of the S&E immigrants admitted in 1992 were born in the Far East, primarily India (3,600), China (3,100), and Taiwan (2,400). Also, Poland, the United Kingdom, the Philippines, the newly independent states of the former Soviet Union, Hong Kong, Iran, and Canada each accounted for at least 500 of the scientists and engineers who immigrated to the United States in 1992. (See appendix table 3-18.)

The annual number of S&E immigrants admitted to the United States during the 1980s ranged between 9,500 and 13,000. During the 1970s and 1980s, there was only minor, gradual shifting in the shares of immigrants from various regions of the world. The proportions of immigrants born in Western Europe, the Near and Middle East, and the Western Hemisphere rose slightly; while the proportion born in the Far East declined from 52 percent in 1976 to about 43 percent in 1990. (See figure 3-15.)

After 1990, however, there were some dramatic changes in the proportions of S&E immigrants from the various world regions:

- ◆ The share of S&E immigrants from countries in the *Far East* increased from 43 percent in 1990 to 55 percent in 1992.

Figure 3-15.
Immigrant scientists and engineers, by region of birth



See appendix table 3-18. *Science & Engineering Indicators – 1993*

Text table 3–6.
Scientists and engineers from the former Soviet Union admitted to the United States on permanent visas

	1982	1983	1984	1985	1987	1989	1990	1991	1992
Total scientists and engineers	768	255	189	125	116	440	646	1,561	826
Engineers	562	204	148	90	79	351	479	1,253	588
Math. scientists & computer spec.	112	17	11	6	7	23	96	102	83
Natural scientists	67	29	19	19	17	40	40	118	104
Social scientists	27	5	11	10	13	26	31	88	51

SOURCE: Immigration and Naturalization Service, unpublished tabulations by Science Resources Studies Division, National Science Foundation.

Science & Engineering Indicators – 1993

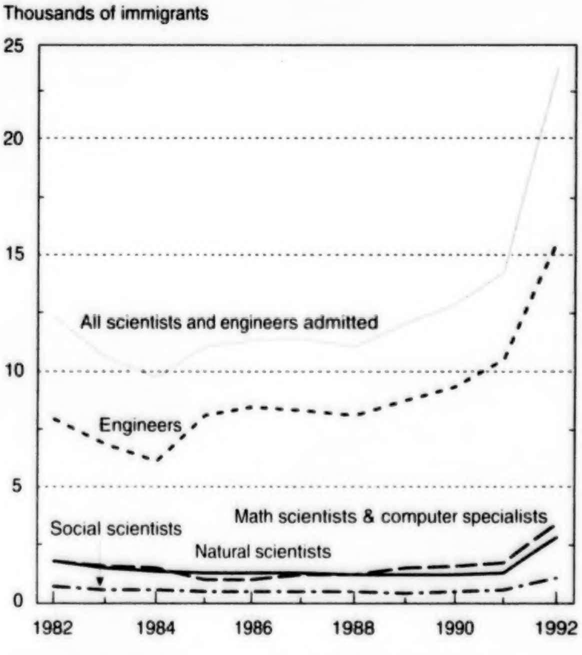
- The proportion from *Central and Eastern Europe* increased from 12 percent in 1990 to 18 percent in 1991, but then dropped back down to 12 percent in 1992. The 1991 increase was caused by an unprecedented number—1,561—of scientists and engineers emigrating from the former Soviet Union. (See text table 3-6).
- The share of S&E immigration represented by each of the other regions—*Western Europe, the Near and Middle East, Africa, and the Western Hemisphere*—fell during the 1990s.

Fields of Employment. Annually, two-thirds to three-quarters of the S&E immigrants admitted to the United States are engineers. (See figure 3-16.) In 1992, 15 percent were mathematicians or computer specialists, 12 percent were natural scientists, and 5 percent were social scientists.

Foreign-born engineers are particularly prevalent on U.S. college campuses (where many of them earned their doctorates). Many of these immigrants are teaching, thereby helping ease a shortage of engineering faculty caused by a decline in the number of U.S. citizens who pursued engineering doctoral degrees in the previous decade. Certain engineering jobs in U.S. industrial firms—those with a Pentagon connection—require U.S. citizenship, so many immigrants have an easier time finding jobs on college campuses. Without these immigrants, some engineering schools would have had difficulty surviving (see Barber and Morgan 1987, 1988). But there is a downside to the increasingly foreign makeup of many engineering departments: Reports of language (see Barber, Morgan, and Torstrick 1987) and cultural barriers have surfaced, the latter leading to charges of insensitivity toward women and minorities (see Vetter 1992a). There is also the view held by some labor market economists that easy access of foreign nationals to U.S. college campuses lets the United States continue to ignore its responsibility to develop science and engineering talent among women and underrepresented minorities (Bergmann 1992).

Few would disagree that immigrants with doctorates in engineering are making a valuable contribution to the U.S. economy and that without them, U.S. educational institutions' engineering departments would face a serious dilemma. There is less consensus on the immigration of engineers; efforts to increase immigration are sometimes seen as a means of keeping wages depressed (Engineering Manpower Commission 1991b). There is also concern about the economic consequences of the "brain drain" on both developed and developing countries. There is some evidence that an increasing number of foreign nationals—especially those from Taiwan and South Korea—are returning to their home countries (see chapter 2 and SRS 1993a).

Figure 3-16.
Scientists and engineers admitted to the United States on permanent visas



See appendix table 3-18. *Science & Engineering Indicators – 1993*

International Comparisons

A country's employment of scientists and engineers is a significant indicator of its level of effort in, and relative national priority for, science and technology. International comparisons are complicated, however, by differences in countries' definitions of specific jobs and in methods of data collection and estimation. Still, international employment data provide insight into the relative strengths of S&E workforces globally. This section presents data and limited comparisons on the S&E workforce in Canada, France, Germany,[37] Italy, Japan, Sweden, the United Kingdom, and the United States.

S&E Employment as a Proportion of the Labor Force

More nonacademic scientists and engineers are employed in the United States—3.5 million—than in any other major industrialized country. Japan ranks a distant second with 2.3 million nonacademic scientists and engineers. (See appendix table 3-19.) Until recently, the United States also had the highest proportion of its labor force employed as scientists or engineers—328 per 10,000 workers in 1986. More recent data, however, show the U.S. ratio at 298—below that for Sweden (522), Japan (380), and the United Kingdom (328).

Employment of Women

The United States has had more success than the other industrialized countries studied in attracting women into the nonacademic S&E workforce. (See appendix table 3-19.) It has the highest proportion of female scientists in the labor force (54 per 10,000 workers). Canada ranks second with 48, followed by Sweden (43), France (36), and the United Kingdom (32). Among these countries, the United States has the second highest proportion of female engineers (13 per 10,000 workers); Sweden has a higher ratio of female engineers—16. Although women are vastly underrepresented in engineering in all industrialized nations, their numbers have been increasing. For example, in the United States, the ratio of female engineers per 10,000 workers rose from 8 in 1986 to 13 in 1992. In Japan, it rose from 3 in 1985 to 8 in 1990.[38]

Employment by Sector

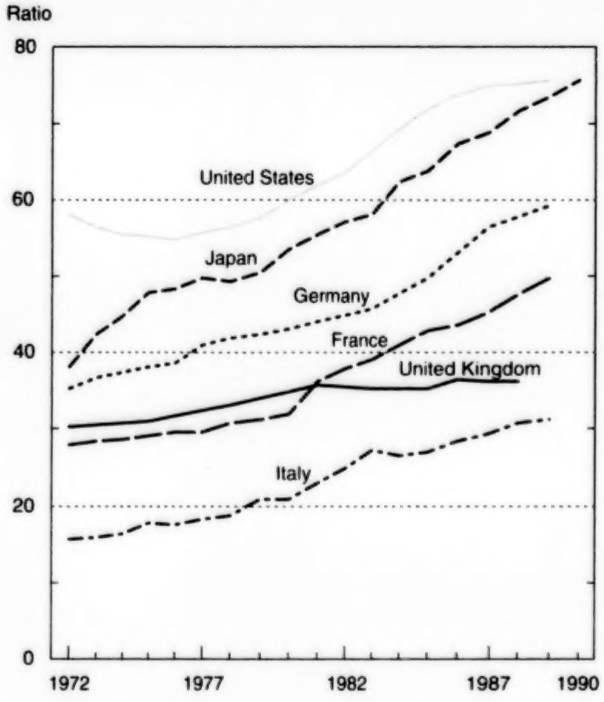
In five of seven major industrialized countries,[39] the *services sector* is the leading employer of *scientists.* Germany[40] and the United Kingdom are the exceptions—in both countries, the manufacturing sector employs the largest number of such scientists. The manufacturing sector is the second largest employer of scientists in the other five countries. In the United States, the government sector employs the third highest number of nonacademic scientists. (See appendix table 3-20.)

The *manufacturing* sector was the largest employer of nonacademic *engineers* in six of the seven countries compared. The proportions ranged from 31 percent in Canada to nearly half in Sweden, the United Kingdom, and the United States. In Japan, however, more engineers are employed in the services sector than in manufacturing.

Across all countries, engineers considerably outnumber scientists in manufacturing. (See appendix table 3-21.) By occupation, industrial/mechanical engineers constituted at least half of the S&E manufacturing workforce in the United States, the United Kingdom, and Sweden. The proportion of these engineers was also high in France, Germany, and Canada, where they accounted for between 41 and 43 percent of all scientists and engineers employed in manufacturing.

The distribution of the Japanese S&E manufacturing workforce differs from that of the other countries. In Japan, the largest proportion of its S&E manufacturing workforce was civil engineers (32 percent). (For all other countries, except Germany, civil engineers accounted for no more than 5 percent of the manufacturing S&E

Figure 3-17.
Ratio of R&D scientists and engineers per 10,000 workers in the general labor force, by country



NOTE: German data are for the former West Germany only.

See appendix table 3-22. *Science & Engineering Indicators – 1993*

workforce.) Japan had the smallest proportion of natural scientists (4 percent) employed in manufacturing.

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[37] German data in this section are for the former West Germany only.

[38] Center for International Studies, U.S. Census Bureau, and unpublished NSF data.

[39] The comparison in this section does not include Italy.

[40] German data in this section are for the former West Germany only.

R&D Employment

The United States had more FTE scientists and engineers engaged in R&D in 1989 than did Japan, Germany, France, the United Kingdom, Italy, and Sweden combined. (See appendix table 3-22.) In fact the United States had twice as many R&D scientists and engineers as Japan and about five times as many as Germany. As a proportion of the labor force, however, Japan now has approximately the same concentration of R&D scientists and engineers as does the United States. Japan's 1990 ratio of R&D scientists and engineers per 10,000 labor force—75.6—was exactly the same as the 1989 U.S. ratio. (See figure 3-17.)

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Chapter 4

Research & Development: Financial Resources and Institutional Linkages

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HIGHLIGHTS

NATIONAL TRENDS

- **Continued slow growth is indicated for the Nation's R&D investments.** U.S. support for R&D grew at an estimated average annual constant dollar rate of 0.9 percent between 1985 and 1993, or one-sixth the 5.3-percent rate for the 1975-85 period. Total R&D expenditures reached an estimated $161 billion in 1993, or 2.6 percent of gross domestic product (GDP).

- **The United States leads all other countries in terms of the amount spent on R&D.** Although the United States spent 11 percent more on *total* R&D in 1991 than did Japan, the former West Germany, and France combined, these three countries collectively spent 17 percent more on *nondefense* R&D. However, only in Japan has nondefense R&D grown notably faster than in the United States since the early 1980s.

- **There has been a worldwide slowing in R&D funding growth since the late 1980s.** Sluggish R&D growth—and even decline—is recently indicated for each of the seven major research-intensive industrialized countries.

- **The Federal Government provides a decreasing fraction of U.S. R&D support.** The federal share of the Nation's R&D funding total edged downward from 46 percent in 1985 to an estimated 42 percent in 1993. Industry's share of total increased slightly during this period, from 51 to 52 percent. The combined share of state government, university, and nonprofit support grew from 3 to 6 percent.

- **Universities account for an increasing proportion of U.S. R&D performance.** The share of all R&D that was conducted in academic institutions—excluding associated federally funded R&D centers (FFRDCs)—grew from 9 percent in 1985 to 13 percent in 1993. Industrial firms' R&D performance share fell from 72 to 68 percent over the same period. R&D undertaken in federal agencies' intramural labs and all FFRDCs combined annually accounted for 16 to 17 percent of the U.S. total.

- **The character of R&D activities is shifting.** Development declined from 65 percent in 1985 to an estimated 59 percent in 1993 as a proportion of the Nation's R&D total. Applied research grew from 22 to 25 percent, and basic research increased from 13 to 16 percent. The increasing complexity and interrelatedness of R&D activities may make these conceptual distinctions less useful in the current research environment than they had been previously.

- **Health accounts for a rapidly growing share of the Nation's total R&D investment.** The National Institutes of Health (NIH) estimates that about 18 percent of combined federal, state, and local government R&D support is health-related, and that most of it is provided by NIH. Similarly, about 18 percent of all privately funded R&D is health-related. Health's share of the Nation's R&D total was about 12 percent in 1985.

- **The state distribution of R&D performance is highly concentrated and relatively stable.** R&D carried out in 10 States accounted for 67 percent of the 1991 U.S. expenditure total. California alone accounted for a 20-percent share. This geographic concentration is not new; in 1975, these same 10 States represented 64 percent of the R&D performed nationwide.

FEDERAL TRENDS

- **U.S. Government R&D funding priorities are shifting.** Defense accounts for 59 percent of the estimated 1994 federal R&D effort, down from its 69-percent peak share of 1987. Most federal growth since then has been in health research—much of it AIDS-related—and space research, primarily for Space Station Freedom. Since 1990, considerable growth is indicated for the industry-related applied research programs of the Department of Commerce and for university-performed basic research funded by the National Science Foundation.

- **Federal research support is concentrated in particular fields of science.** Funding for the life sciences dominates federal basic research totals (46 percent in 1993) and has grown steadily since the early 1980s. One-third of federal applied research support is for the life sciences and one-third for engineering, primarily aeronautical.

- **Individual investigators receive a slightly smaller share of federal civilian academic research support than in the past.** From 1980 to 1989, the share of such funds going to individual investigators declined from 56 to 51 percent. The proportion of federal nondefense academic support that funds research teams and major facilities increased somewhat.

- **Federal R&D support is increasingly tied to specific multi-agency initiatives.** As part of an overall strategy to use science and technology to achieve national goals, the 1994 budget targeted $12.5 billion for six presidential initiatives, ranging from global environmental change research to science and math education.

- **Considerable change is under way in the Department of Defense (DOD) post-Cold War budgetary plans.** R&D accounts for 14 percent ($38 billion) of DOD's estimated total 1994 outlays ($269 billion), up from its 10-percent share ($13 billion of the $132 billion DOD total) at the beginning of the defense buildup in 1980. In DOD's new Science and Technology Program, government R&D is emphasized as a way to maintain the Nation's defense technology base. DOD has relaxed its criteria defining those industry independent R&D projects that it will reimburse. Additionally, DOD is funding out of its R&D budget a multi-agency defense conversion program to bolster economic competitiveness and promote dual-use technologies.

INDUSTRY TRENDS

- **Direct federal R&D support to industry is highly concentrated and occasionally targeted.** Federal funds account for just one-fourth of the money used for industrial R&D performance; aerospace and communication equipment firms receive 76 percent of this federal support total. Federal agencies also provided one-third of the R&D funds used by ***nonmanufacturing*** industries in 1991. Moreover, during the past decade, more than $3 billion in federal R&D support has been awarded to ***small businesses*** through the Small Business Innovation Research program.
- **Considerable indirect federal R&D support is provided to industry.** Since 1981, more than $20 billion has been provided to industry through tax credits on incremental research and experimentation expenditures.
- **Federal labs are accelerating efforts to help industry make commercial use of their research.** Over 1,500 cooperative agreements have been negotiated between federal labs and industry since 1987, and the number of licensing agreements has more than doubled. Also, the Nation's large weapons labs have incorporated civilian technology transfer activities into their mission goals.
- **Industry is expanding its use of domestic research collaboration.** The number of university-industry research centers has grown rapidly during the past decade. An estimated 1,058 centers were in existence in 1990. More than 350 multi-firm cooperative research ventures, including R&D consortia, have been registered nationwide since 1985.
- **Industry's use of international research partnerships is expanding.** The number of known international multi-firm R&D alliances grew from about 250 in the 1970s to almost 1,500 in the 1980s.
- **The internationalization of industrial R&D activities is intensifying.** In 1991, the overseas R&D investment by U.S. companies was equivalent to 11 percent of industry's domestic R&D spending compared to 6 percent in 1985. In 1990, foreign companies accounted for an amount equivalent to 15 percent (majority-owned foreign affiliates for 11 percent) of all industrial R&D expenditures in the United States, compared to their 9-percent share in 1985. Also, about one-half of the 255 foreign-owned R&D facilities in the United States in 1992 had been established during the previous 6 years.

Introduction

Chapter Background

The United States spent an estimated $161 billion on research and development (R&D) activities in 1993.[1] This investment in the discovery of new knowledge—and in the application of knowledge to the development of new and improved products, processes, and services—was equivalent to 2.6 percent of the total U.S. gross domestic product (GDP). The absolute magnitude of the effort and the manifold tasks to which it is directed are indicative of the critical role that R&D plays in addressing such concerns as national defense, industrial competitiveness, public health, environmental quality, and social well-being. Indeed, the long-term importance of R&D expenditures to technological preeminence, military security, and knowledge growth is axiomatic.

There is widespread agreement within both the public and private sectors that this national investment needs to be more closely monitored and evaluated. The past two decades bore witness to truly profound changes in the economic, political, and research environments in which science and technology (S&T) policy is determined and R&D activities are conducted. Coupled with substantial shifts in the Nation's overall inflation-adjusted R&D funding levels (see figure 4-1), there have been vast changes in the organizational and institutional aspects of research funding. Industry, challenged by the competitive demands of an increasingly integrated global economy,

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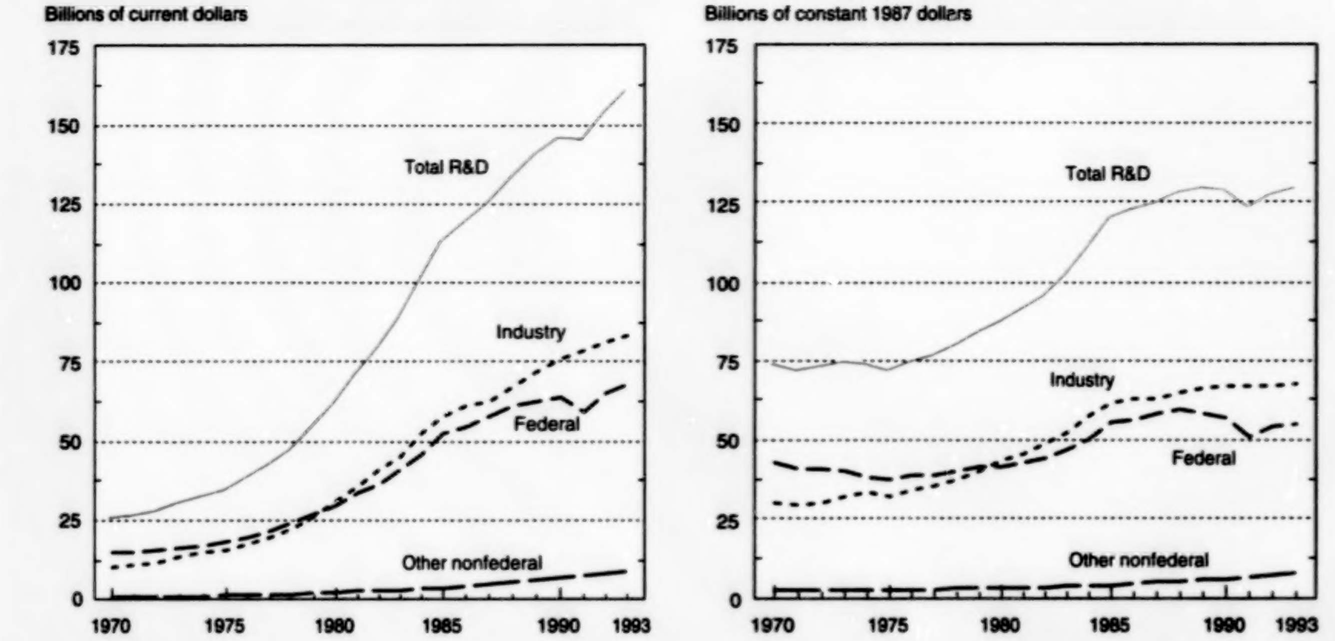
[1] Throughout this chapter, current funding or expenditure data are presented in nominal dollars. In keeping with U.S. Government and international standards, R&D trend data usually are deflated to 1987 constant dollars using the GDP implicit price deflator and are so indicated. (See appendix table 4-1.) Since GDP deflators are calculated on an economy-wide rather than R&D-specific basis, their use more accurately reflects an "opportunity cost" criterion, rather than a measure of cost changes in doing research. The constant dollar figures reported here thus should be interpreted as real resources foregone in engaging in R&D rather than in other activities such as consumption or physical investment. Broad-based deflators—such as the GDP deflator—are, however, quite useful in approximating changes in aggregate R&D costs (Jankowski 1993). They are undoubtedly much *less* appropriate for calculating real R&D expenditures at a more disaggregated level.

Figure 4-1.
National R&D funding, by source



See appendix table 4-4.

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is going through a difficult period of restructuring and downsizing in which R&D activities have to compete vigorously with other, more short-term, company priorities. The need to leverage scarce R&D funds has become unquestionably apparent, and industry's effort to do so is indicated by impressive growth in its research partnerships with federal and academic institutions as well as with various domestic and international competitors.

Public policy is also in a period of rapid evolution and fundamental reassessment: Tension between the desire for new research initiatives and the need for significant budgetary cutbacks is evident throughout government. Pronouncements by both the executive branch and Congress have underscored the urgency of setting research priorities and revisiting assumptions around which national R&D funding decisions have long been guided. As budget-strapped state and federal agencies each struggle with the conflicting desire to do more—or at least better—with less, the situation has given rise to new forms of research coordination and institutional arrangements for managing funding agencies' R&D support. On top of this, the end of the Cold War offers an untold host of opportunities and challenges to the Nation's S&T enterprise. Throughout the 1980s and into the 1990s, more than one-half of the government's—and one-quarter of the Nation's—R&D resources were devoted to deterring the massive military threat posed by the Soviet Union. With the fall of Soviet Communism, a major task facing the Nation is to shift these resources to activities that not only address remaining current and future defense needs, but also confront the international economic challenges at the forefront of domestic policy concerns.

Chapter Organization

The chapter is organized into three separate, interrelated parts. The first part describes broad patterns among R&D-funding and -performing sectors—the Federal Government, industry, academia, and nonprofit institutions. The character of these activities—that is, whether they are basic research, applied research, or development—also is discussed. The focus of the coverage is on current expenditure patterns, although trend material is presented on R&D activities covering the past 15 years. In addition, national R&D spending patterns are analyzed (1) with reference to the distribution of these activities by state, and (2) in comparison with those of other major R&D-performing countries.

The second part considers the federal role in the national effort in more detail. Transfers of federal funds to the various R&D-performing sectors are detailed, with specific attention given to the funding agencies, the fields of research funded, and the various socioeconomic objectives—including defense and nondefense—supported. Patterns of U.S. Government R&D support are compared with those of its international counterparts. Government's defense-related R&D activities, including defense conversion issues, are covered in some detail. Other topics addressed are changes in the structure of federal R&D support, including ways in which federal agencies provide support for academic research, and use of interagency cross-cutting initiatives in prioritizing federal R&D expenditures.

The concluding part looks at growth of industrial R&D linkages. The industry-federal R&D funding relationships that were introduced in the first two parts of the chapter are further developed: Particular attention is given to R&D expenditure patterns within specific industries. Data are provided on federal incentives put in place to foster industry R&D growth indirectly—for example, R&D tax credits; also presented are a series of indicators related to the transfer of technologies developed in federal labs to the private sector. In addition, there is material documenting industry's increased reliance on multi-firm and multi-sector research partnerships. Topics include the growth of university-industry research centers, domestic research consortia, international technology agreements, and flows of R&D funds moving both into and out of the United States. Similar trends for other major R&D-performing countries are identified.

National R&D Spending Patterns

During the 1980s and early 1990s, important broad structural changes in the conduct and support of U.S. R&D activities have taken shape. Industry has replaced the Federal Government as the Nation's largest source of R&D support, even as industry's share of the R&D performance total has fallen considerably. State and industry funding of university research has expanded greatly in recognition of the contributions of such research to economic development and commercial competitiveness. The focus of federal R&D funding also is shifting, moving away from defense and toward civilian strategic concerns. These changes are likely to continue—and even accelerate—in the foreseeable future. An understanding of the present situation therefore provides a framework for assessing future S&T developments. In this section, national R&D expenditure trends and sector-specific R&D funding and performance patterns are reviewed. Broad changes in R&D spending patterns since the early eighties are identified, and recent estimates of the Nation's 1993 R&D expenditures are summarized. The geographic distribution of the Nation's R&D activities is presented, and the discussion closes with a comparison of the nationwide U.S. R&D effort to those of other major research-oriented countries.

Aggregate Trends: From Growth to Leveling

The Nation's R&D expenditures rose rapidly and dramatically from the mid-seventies through the first half of the eighties, climbing from about $72 billion in 1975 (in constant 1987 dollars) to more than $120 billion in 1985. (See figure 4-1.) During this 10-year period, U.S. R&D spending grew on average 5.3 percent annually, and the R&D/GDP ratio rose from 2.2 to 2.8 percent. Both federal and nonfederal sectors contributed to this R&D growth. Initially, much of the period's research expansion was directed toward solutions to energy problems; by the early eighties, however, the focus of the national R&D effort had shifted overwhelmingly toward defense-related—particularly development—activities.

This period of rapid R&D growth was relatively short-lived. Sluggishness in the economy and its attendant negative impact on profits—profits out of which commercial R&D projects are normally funded—slowed private investment in R&D activities.[2] Budgetary constraints imposed on virtually all federal and state government programs—as well as reprioritization of such programs—have since served to reduce R&D gains from the public sector as well.[3] The conclusion of the Cold War, and the resultant restructuring and drawdown of the Nation's military technological base has already, and likely will further, affect R&D funding choices. As a result of these varied influences, total inflation-adjusted expenditures for R&D have been virtually flat since 1985. Moreover, fueled particularly by a reduction in defense R&D spending, they even declined in 1990 and 1991.[4] National R&D growth slowed to a 0.9-percent average annual constant dollar rate of increase during the entire 1985-93 period, and total R&D expenditures seem to have plateaued—at least temporarily—at about $130 billion (constant 1987 dollars) in 1993: The Nation's R&D/GDP ratio edged downward to an estimated 2.6-percent share of total.[5]

R&D Funders. Total funds for R&D in the United States ($161 billion in nominal terms) came mainly from two sources in 1993—industry (at an estimated 52 per-

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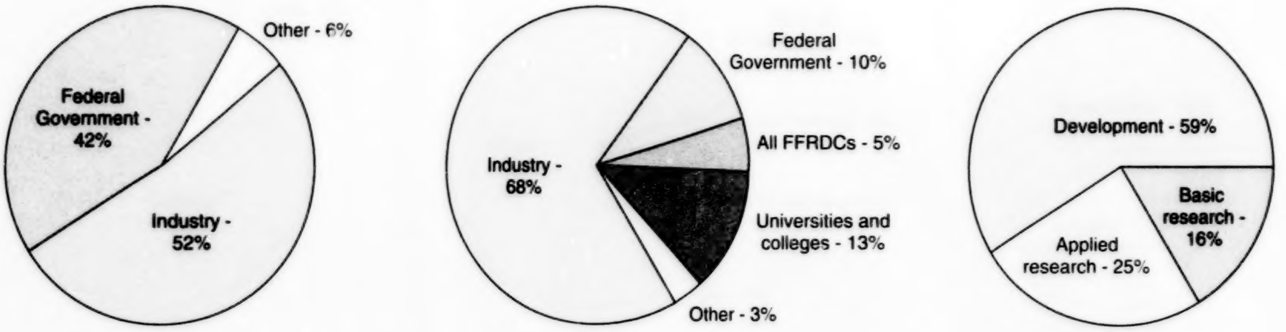
[2] There are undoubtedly additional reasons beyond reduced sales and profit expectations for the recent slowing in industry's R&D effort. The drop in military R&D has certainly affected government spending and probably industry's as well. Indeed, some industry officials cite the decline in federal R&D contracting and "unspecified business conditions" as the major reasons for the deceleration in their R&D funding (SRS 1992a and NSB 1992a). Officials also note that increases in the real cost of capital and in the number of corporate mergers and acquisitions may have somewhat curbed R&D growth rates, the latter point being recently confirmed in a study by Long and Ravenscraft (1993). Their findings, however, do not support the view that R&D cutbacks—on average—*caused* a decline in the restructured companies' overall economic performance: They instead note only that R&D spending tends to be curtailed in companies that have undergone a leveraged buyout.

[3] A recent report from the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine (1993) noted that R&D funding above current levels is not necessarily required to meet current societal S&T goals. The report's authors, who represent some of the Nation's foremost scientists and engineers, observe that policy debates too narrowly focused on raising absolute amounts can be counterproductive, and that more attention should be given to choosing which science activities are supported with public funds.

[4] The specific cause for a $5 billion federal R&D funding drop in 1991 is unknown. To a large extent, the decline appears to reflect reduced support from the Air Force and Navy to industry performers. About half of the decline was, apparently, the result of a delay in R&D project funding, *not* a permanent cutback due to defense downsizing.

[5] For recent summaries of national R&D funding trends and shifts in R&D policy, see Cohen and Noll (1993), Mowery and Rosenberg (1993), and Reid (1993).

Figure 4-2.
National R&D expenditures: 1993



By source of funds **By performing sector** **By character of work**

NOTE: FFRDC = federally funded research and development center.
See appendix tables 4-4, 4-5, 4-6, and 4-7.

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cent of total) and the Federal Government (42 percent of total). The remaining 6 percent came from universities and colleges, state and local governments, and nonprofit institutions.[6] (See figure 4-2.) The most recent estimates show industry support increasing 1 percent (constant 1987 dollars) from 1992 to 1993, federal support rising about 2 percent, and support from other nonfederal sources climbing 8 percent. Overall, this equates to less than a 2-percent inflation-adjusted rate of increase.[7] (See appendix table 4-3.)

Although most of industry's and academia's R&D support go to performers in their own sectors, this is not the case with the Federal Government. Federal R&D expenditures reached an estimated $68 billion in 1993. Of this,

- 46 percent funded industry and affiliated federally funded research and development centers (FFRDCS);[8]
- 24 percent funded federal in-house intramural R&D performance;
- 17 percent went to universities and colleges;
- 8 percent funded FFRDCS administered by universities; and
- 5 percent was for institutions in the nonprofit sector, including FFRDCS administered by nonprofits. (See text table 4-1.)

The 1993 sectoral funding shares for the Nation differ somewhat from those of less than a decade earlier. The most notable change concerns the relative roles of the Federal Government and private industry. For example, the federal contribution to R&D funding levels was considerably higher in 1985, when it accounted for a 46-percent share of total—4 percentage points more than the 1993 share.[9] In contrast, private firms have slowly increased their relative share of support for total U.S. R&D activities, rising from 49 percent of the 1980[10] total, to 51 percent of the 1985 total, and to a current 52-percent share. This industrial support includes both in-house R&D and funding of R&D in other sectors. The share of R&D support from all other nonfederal sectors also has risen, from a 3-percent share of total in 1985 to 6 percent in 1993. (See appendix table 4-3 for background data.) Given the evolving pattern of collaborative research among the various performing sectors (described throughout this chapter), the increased diffusion in R&D funding sources is a trend unlikely to be reversed in the near future.

R&D Performers. At an estimated $109.3 billion in 1993, industry (exclusive of its affiliated FFRDCs) remains the largest performer of R&D in the United States. R&D performed by companies accounted for 68 percent of the national R&D effort.[11] (See figure 4-2.) Aerospace companies accounted for about one-fifth of industry's performance total; companies in the chemicals, computers, communication equipment, and motor vehicles industries each accounted for about 10 percent.

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[6] Current estimates for state governments' *in-house* R&D are not available. In 1988, state labs' intramural performance reached $0.5 billion (SRS 1990). Thus, national R&D expenditures totaled an estimated $134.2 billion in 1988, rather than the $133.7 billion reported in appendix table 4-3.

[7] The estimates of 1993 R&D funds are from SRS (1993d). Additional forecasts of industrial R&D expenditures are available from Battelle (1993) and Industrial Research Institute (1993).

[8] An FFRDC is an organization exclusively or substantially financed by the Federal Government to meet a particular requirement or provide major facilities for research and associated training purposes. Each center is administered by an industrial firm, an individual university, a university consortia, or a nonprofit institution.

[9] Indeed, the federal portion of the U.S. R&D support total has fallen rather steadily since 1964, when it accounted for about a 67-percent share.

[10] This was the first year since such statistics had been collected that industrial R&D funding surpassed that of the Federal Government.

[11] The 10 industry-administered FFRDCs performed an estimated $2.7 billion of R&D in 1993. They received the bulk of their funding from the Department of Defense and the atomic energy defense programs of the Department of Energy.

The second largest R&D-performing sector is the Nation's universities and colleges, exclusive of university-administered FFRDCs; this sector accounted for 13 percent ($21 billion) of the U.S. R&D total. Federal funding provided for an estimated 55 percent of academic R&D activities in 1993; this was down from a 68-percent federal share in 1980.

Federal *in-house* R&D (exclusive of all FFRDCs) accounted for an estimated 10 percent ($17 billion) of the Nation's 1993 R&D total. This federal intramural performance is down 2 percent (in constant dollars) from estimated 1992 levels.

The 1993 numbers for all industry represent a 2-percent gain. Universities' R&D performance growth (an estimated 5 percent after general inflation is taken into account) outpaced that of all other sectors in 1993, as it generally has in each of the last 8 years.

Recent changes in R&D *performance* patterns have been as pronounced as the changes in the *funding* structure of R&D activities. The main beneficiary of the relative shifts in these patterns has been the academic sector. Industry's 68-percent share of the Nation's 1993 R&D performance total represents just a slight decline from its 69-percent share of the 1980 total, but is substantially less than the 72-percent performance share held as recently as 1985. About 26 percent of industry's 1993 R&D performance was financed by the Federal Government (see text table 4-1), mostly by the Department of Defense (DOD). The heavy dependence of some industries on a declining DOD budget is one of the main reasons for the recent relative drop in this sector's performance share.[12]

Universities and colleges increased their portion of the R&D performance total over the same period, rising from 9 percent in 1985 to their present 13-percent share. This growth in R&D performed on the Nation's campuses benefited from steadily proliferating industry-university partnerships with both federal and state government funding.[13]

The R&D performance of federal intramural labs declined slightly from an 11-percent national share in 1985 to 10 percent in 1993; the share for all FFRDCs was about 5 percent of the respective 1985 and 1993 totals. Consequently, R&D expenditures in all federal labs accounted for 16 percent of the national total in 1993, down from a 19-percent share in 1980 and a 17-percent share in 1985.

Character of Work. Although the varying goals of basic and applied research and development make these activities conceptually distinct, this distinction has, in many fields, become somewhat blurred. Research can be directly influenced *both* by the quest for fundamental knowledge and by considerations of use—that is, some basic research is not driven by curiosity alone, but is explicitly undertaken to achieve applied goals and car-

Text table 4–1.
National R&D expenditures, by performing sector and source of funds: 1993 (est.)

R&D performers	Total	Sources of R&D funds				Percent distribution, performers
		Industry	Federal Government	Universities and colleges[1]	Nonprofit institutions	
	Millions of dollars					
Total	160,750	83,550	68,000	6,000	3,200	100.0%
Industry	109,600	81,300	28,300	—	—	68.2
Industry-administered FFRDCs[2]	2,700	—	2,700	—	—	1.7
Federal Government	16,600	—	16,600	—	—	10.3
Universities and colleges	20,550	1,500	11,400	6,000	1,650	12.8
University-administered FFRDCs[2]	5,300	—	5,300	—	—	3.3
Nonprofit institutions	5,300	750	3,000	—	1,550	3.3
Nonprofit-administered FFRDCs[2]	700	—	700	—	—	0.4
Percent distribution, sources	100.0%	52.0%	42.3%	3.7%	2.0%	

— = unknown, but assumed to be negligible

[1] Includes an estimated $1.85 billion in state and local government funds provided to university and college performers.

[2] Federally funded research and development centers (FFRDCs) conduct R&D almost exclusively for the Federal Government. Expenditures for FFRDCs are therefore included in federal R&D support, although some nonfederal R&D support may be included in the totals.

See appendix table 4–3.

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[12] Industry-specific funding details for domestic firms are presented later in this chapter ("Industry-Government Interactions"). Industry comparisons with U.S. international competitors are summarized in chapter 6.

[13] See "Industry-University Partnerships" and chapter 5 for other indicators of these trends.

Definitions

The National Science Foundation uses the following definitions in its resource surveys.

Basic research: The objective of basic research is to gain more complete knowledge or understanding of the subject under study, without specific applications in mind. In industry, basic research is defined as research that advances scientific knowledge but does not have specific immediate commercial objectives, although it may be in fields of present or potential commercial interest.

Applied research: Applied research is aimed at gaining knowledge or understanding to determine the means by which a specific, recognized need may be met. In industry, applied research includes investigations oriented to discovering new scientific knowledge that has specific commercial objectives with respect to products, processes, or services.

Development: Development is the systematic use of the knowledge or understanding gained from research directed toward the production of useful materials, devices, systems, or methods, including the design and development of prototypes and processes.

Budget authority: Budget authority is the authority provided by federal law to incur financial obligations that will result in outlays.

Obligations: Federal obligations represent the amounts for orders placed, contracts awarded, services received, and similar transactions during a given period, regardless of when the funds were appropriated or payment is required.

Outlays: Federal outlays represent the amounts for checks issued and cash payments made during a given period, regardless of when the funds were appropriated or obligated.

ried out in projects that have strategic objectives. The S&T enterprise is replete with examples of scientific advance and technological innovation attained through the blending of basic and applied research and experimental development work or by combining the knowledge base of multiple disciplines. Ongoing research by Mansfield (1993), based on interviews with corporate executives, and Narin and Stevens (1993), using bibliometric data, further confirms the close and overlapping importance of academic—generally basic—research to industry's applied technology concerns.[14] Despite the indistinct and interrelated aspects of the traditional character of work categories (see "Definitions"), examining the distribution of the Nation's total R&D investment among these categories provides an indication of *intended* sectoral funding priorities, as well as information on changes in public and private R&D strategies.[15]

Development continues to account for the lion's share —59 percent—of U.S. R&D funds. An estimated 25 percent of the 1993 R&D total was for *applied research*; the remaining 16 percent was *basic research*. Each of the sectors funds and performs basic research, applied research, and development to varying degrees. Different sectors, however, dominate in these R&D work categories:

- In 1993, industry—including FFRDCs administered by industrial firms—performed 86 percent and funded 61 percent of *development*. The Federal Government funded most (38 percent) of the remainder.
- Industry performed 67 percent and funded 53 percent of the *applied research* total. Here again, the Federal Government funded almost all—39 percent—of the rest.
- The academic sector performed 62 percent of all *basic research*: Universities and colleges accounted for 51 percent of total, and their affiliated FFRDCs for 11 percent. The Federal Government funded 63 percent of the Nation's basic research total. (See figure 4-3.)

Since the mid-eighties, there has been a notable shift in relative emphasis by character of work. These changes are indicative of the broader shifts under way in the sources of R&D support and in sectoral funding priorities. As a proportion of total R&D,

- development has declined from 65 percent in 1985 to its current estimate of 59 percent,
- applied research has risen from 22 to 25 percent, and
- basic research has climbed from 13 to an estimated 16 percent. (See appendix tables 4-4, 4-5, 4-6, and 4-7.)

State Distribution of R&D Spending

Many States have pinned their hopes for economic development and prosperity on the growth of science-based high-technology industries. In doing so, they have adopted measures designed to broaden their R&D

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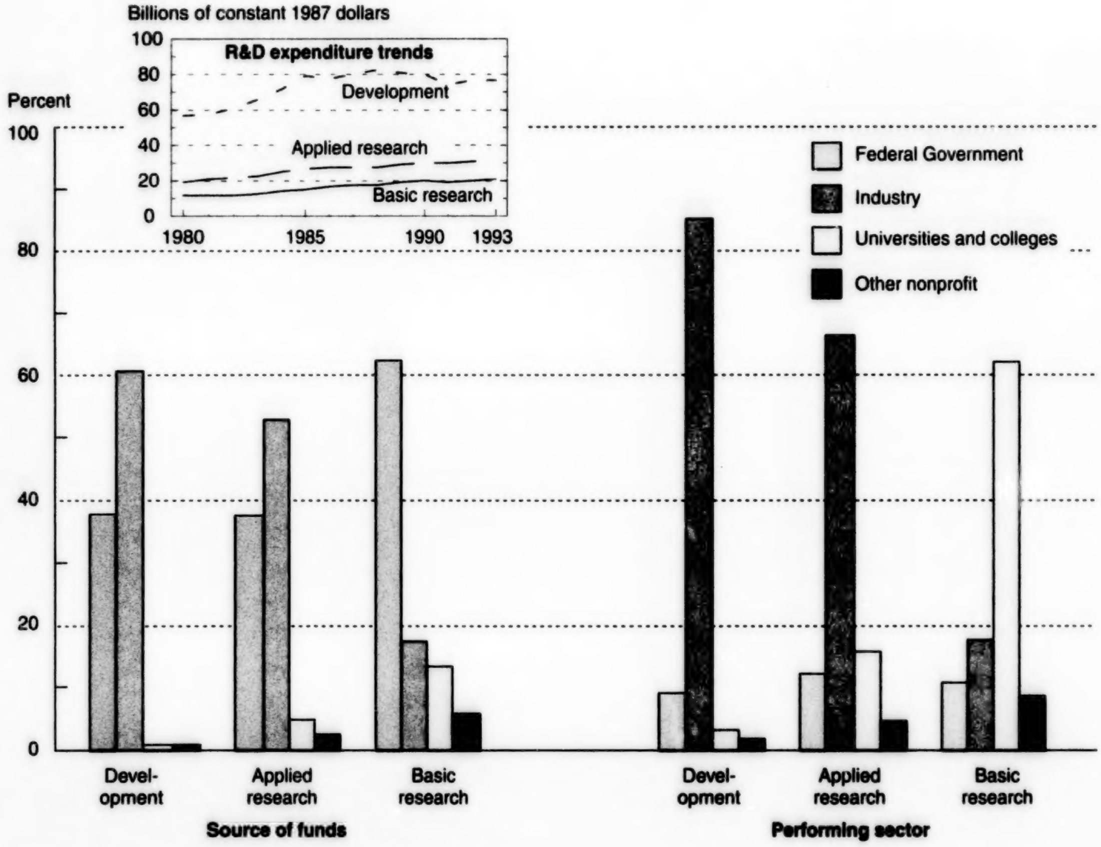
[14] The importance of research and education activities to the *long-term* competitive strength of the Nation is pointedly noted in a recent special report by the National Science Board (1992a).

[15] Nor has this traditional taxonomy lost all of its practical relevance. According to Link's preliminary survey findings (forthcoming), firms in the chemicals, machinery, and electric and electronic equipment industries report that the categories of basic research, applied research, and development accurately describe the scope of R&D that is (1) self-financed and (2) conducted throughout their industry.

Figure 4-3.
National R&D expenditures, funders, and performers, by character of work: 1993



NOTE: Funds for federally funded research and development center performers are included in their affiliated sectors.

See appendix tables 4-5, 4-6, and 4-7.

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infrastructure: Ample evidence suggests that a critical base of research is one of the fundamental requirements for location and growth of high-tech industries in a region.[16] Yet the current geographic distribution of R&D activities stems from innumerable past public and private sector choices made in light of multiple economic and scientific factors and considerations, not all of which are easily amenable to change. Absolute levels of R&D performance therefore are indicators not only of a state's current capacity to support S&T-based economic development but also—to a certain extent—of a state's near-term potential to build on its S&T base. This discussion presents summary material on the geographic distribution of the U.S. domestic R&D effort. The analysis covers state R&D concentration levels—in the aggregate and by sector—and indicators of the research intensity of states' economies.[17]

Top 10 States and Sector Performance Patterns. Half of the $145 billion spent on R&D in the United States in 1991 was expended in six States—California, New York, Michigan, New Jersey, Massachusetts, and Pennsylvania. Moreover, two-thirds of the national R&D effort was performed in 10 States—the preceding six together with Illinois, Ohio, Maryland, and Texas. In California alone, $28 billion—or 20 percent of all U.S. R&D expenditures—were spent; expenditures ranged between $5 and $11 billion in each of the other nine leading States. (See appendix table 4-8.) In contrast, the smallest 30 States collectively accounted for roughly $20 billion (or less than 15 percent) of the R&D conducted nationwide in 1991.

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[16] See NSB (1991), chapter 4, for a summary of several state S&T initiatives in the eighties. There are no systematically compiled and published tabulations available on state S&T and R&D involvement other than the series cited in the 1991 *Indicators* volume. For further discussion of states' increasing role in supporting the Nation's S&T enterprise and on the general absence of reliable data for comparative analysis, see Carnegie Commission (1992c).

[17] This section presents information on where R&D is performed by industry, academia, and federal agencies, and the federally funded R&D activities of institutions that are part of the nonprofit sector. Consistent data on the state distribution of nonfederal R&D expenditures used by nonprofit institutions are not compiled.

Not coincidentally, most of the States that are national leaders in total R&D performance also rank among the leading sites of industrial and academic R&D performance. (See appendix table 4-8.) Of the 10 States that led in total R&D,

- all but Maryland ranked among the top 10 industrial performers, its position being held by Washington State;
- all but New Jersey ranked among the top 10 academic performers, its position being held by North Carolina.

This geographic concentration is not new. For example, the 10 States with the highest R&D performance totals in 1991 were also the top 10 R&D performers in 1975, although their exact ranking has shifted somewhat over time. Between 1975 and 1991, Texas experienced the greatest growth in R&D performance—a growth undoubtedly stemming in part from the State's success in attracting such high-profile research undertakings as Sematech (a consortium to develop manufacturing technologies), the Microelectronics and Computer Technology Corporation consortium, and the Department of Energy's Superconducting Super Collider. Meanwhile, the largest decline in R&D performance *share* was reported for New York, which accounted for 8.1 percent of the U.S. total in 1975, and 7.1 percent by 1991; however, the increase in *actual dollars* spent on in-state R&D activities was greater in New York than in any other State except California. (See text table 4-2 and SRS 1989.) The R&D performance shares of two other top 10 States—Ohio and Pennsylvania—first dipped down, and then increased, during the 1975-91 period. In this context, it is worth noting that both States adopted in the early 1980s what are now nationally renowned S&T programs—the Thomas Edison Program in Ohio and the Ben Franklin Partnership Program in Pennsylvania. Both programs were originally founded specifically to stimulate research and innovative activity.

Text table 4–2.
Share of U.S. R&D, by state in which the R&D is performed

	1975	1985	1991
		Percent	
California	18.6	20.7	19.5
New York	8.1	7.8	7.1
Michigan	6.1	5.9	6.1
New Jersey	5.0	6.3	6.0
Massachusetts	4.9	5.6	5.9
Pennsylvania	5.5	4.0	5.2
Texas	3.0	4.1	4.6
Illinois	4.0	3.9	4.4
Ohio	4.4	3.4	4.1
Maryland	4.7	4.6	4.0
All other[1]	35.7	33.7	33.1

[1] "All other" includes R&D performed in the 40 states not listed and in the District of Columbia, and R&D that could not be allocated to a specific location. Individual states included in "all other" generally account for shares of 2 percent or less.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Geographic Patterns: R&D in the United States*, NSF 89-317. (Washington, DC: NSF, 1989); and SRS, unpublished tabulations.

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According to data recently compiled for the Carnegie Commission on Science, Technology, and Government (1992c), Pennsylvania budgeted more for its technology programs ($32 million in fiscal year 1991) than did any other State. Appropriations for Ohio's technology programs were also substantial in 1991 ($19 million), but were slated to suffer severe budget cuts—about 50 percent—by fiscal year 1993. Estimated 1993 state technology appropriations in Texas were, at $30 million, the largest among all reporting States. In general, the report concludes that state S&T programs have weathered recession-driven budget cuts rather well, especially given the fiscal difficulties facing most States in recent years. Overall, the relative stability in research distribution during the last decade and a half indicates that leading R&D centers are not easily overtaken—especially if there is a concerted effort to fortify an already strong S&T base.

R&D Intensity of State Economies. Just as the ratio of R&D expenditures to GDP is used to gauge a country's commitment to R&D and measure the change in this commitment over time, the ratio of in-state R&D performance to gross state product (GSP) can be used to measure the research intensity of a state's economic activity.[18] Moreover, indicators that normalize for size of states' economies tend to facilitate more meaningful comparisons between states. For the United States, the R&D/GDP ratio was about 2.6 percent in 1991. Ten States and the District of Columbia obtained R&D/GSP ratios above this national average. Interestingly, these were not the same 10 States that accounted for the largest percentage shares of the U.S. R&D effort. (See figure 4-4.)

The largest R&D/GSP ratios were achieved in New Mexico (9 percent) and Delaware (about 6 percent). The high research intensity of New Mexico's economy stemmed primarily from the considerable federal support provided to the several FFRDCs located in the State. Delaware's high R&D/GSP ratio resulted from comparatively large in-State research efforts of the chemicals industry. On the other hand, California and New York

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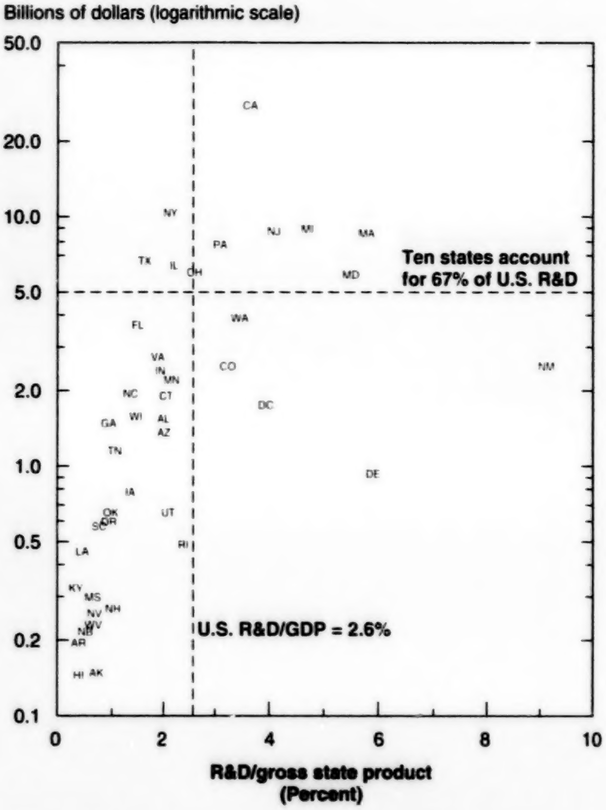
[18] The Bureau of Economic Analysis has prepared GSP data through 1989 and is in the process of updating the data through 1991. GSP data used here were estimated based on annual state changes in employee compensation and proprietors' income. See Renshaw, Trott, and Friedenberg (1988) for a discussion of those components of economic activity that comprise the GSP totals.

Figure 4-4.
R&D performance by state and ratio of R&D/gross state product: 1991



NOTE: R&D data for some states are unavailable or estimated.

See appendix table 4-9. *Science & Engineering Indicators – 1993*

led the Nation in absolute dollars of total R&D performance, but ranked no higher than 8th and 15th, respectively, in terms of their economies' R&D intensity—3.7 percent and 2.2 percent, respectively. There were roughly 15 States in which total R&D activity was less than $0.5 billion in 1991 and the resultant R&D/GSP ratio was under 1 percent.

International Comparisons[19]

Absolute levels of R&D expenditures are indicators of the breadth and scope of a nation's S&T activities. The relative strength of a particular country's R&D effort is further indicated by comparison with other major industrialized countries. This section provides such comparisons of international R&D spending patterns. Performer and source expenditure patterns are contrasted and trend data are reviewed. The trends show that U.S. leadership in terms of its financial investment in R&D vis-à-vis other countries has narrowed considerably during the past two decades, but that more recently there has been a *worldwide* slowing in the growth of such funds. While sectoral R&D performance patterns are quite similar across countries, national sources of support differ considerably. Nonetheless, foreign sources of R&D have been increasing in practically all countries.

R&D Funding by Source and Performer. Just as the performance of R&D activities is heavily localized in the United States, the worldwide distribution of R&D performance is heavily concentrated in several industrialized nations.[20] Of the approximately $350 billion in R&D expenditures estimated for Organisation for Economic Co-operation and Development (OECD) countries, 90 percent is expended in just seven.[21] Accounting for roughly 43 percent of the industrial world's R&D investment total, the United States continues to far outdistance the research investments made by all other countries. Not only did the United States spend more money on R&D activities in 1991 than did any other country, it spent more than the next three largest performers—Japan, Germany, and France—combined.[22] The OECD's other three large R&D performers were the United Kingdom, Italy, and Canada. (See appendix table 4-35.)

These seven countries are fairly similar in terms of R&D performance by sector; their sources of national R&D funding vary somewhat. ***Industry*** was the leading R&D performer in each of the seven countries, with shares reaching 60 percent or more in the United States, Japan, Germany, France, and the United Kingdom.[23] (See figure 4-6.) In Italy and Canada, industry has slightly lower shares, but still accounts for more than one-half

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[19] The R&D data presented here for the major industrialized countries are obtained from reports to the Organisation for Economic Co-operation and Development (OECD), which is the most reliable source of such international comparisons. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) reports the few estimates for developing countries derived from systematic R&D data collection. There is a fairly high degree of consistency in the R&D data reported by OECD: Differences in reporting practices between countries are estimated to affect the R&D/GDP ratios by no more than 0.1 percent (ISPF 1993). Data for countries reporting to UNESCO are less comparable, principally because of differences in national statistical collection capabilities and definitions. For a summary of UNESCO and OECD data, see SRS (1991).

[20] Although several developing countries have greatly expanded the level of national resources they devote to civilian research efforts, the overall financial impact of their efforts is small compared with those of the large industrialized countries. For example, estimated 1990 R&D expenditures in Singapore, Taiwan, South Korea, and India combined was about 10 percent of the U.S. R&D total (SRS 1993c).

[21] Estimates are for 1990; see OECD (1993a). Note that these estimates are based on reported R&D investments converted to U.S. dollars with purchasing power parity (PPP) exchange rates. Although PPPs are not equivalent to R&D exchange rates per se, they better reflect differences in countries' laboratory costs than do market exchange rates. See "Purchasing Power Parities: Preferred Normalizer of International R&D Data."

[22] German data are for the former West Germany alone, and do not include R&D expenditures in the former East Germany.

[23] U.S. totals are reported differently in this section than they are elsewhere in this chapter (see figure 4-2). R&D performance by FFRDCs is included within the administering sector, rather than in the government's performance totals. Also, industrial R&D financed from abroad are reported separately here, rather than included in the industry funding totals.

Purchasing Power Parities: Preferred Normalizer of International R&D Data

Comparisons of international statistics on R&D are hampered by the fact that countries' R&D expenditures are denominated, obviously, in their home currencies. Two approaches are commonly used to normalize the data and facilitate aggregate R&D comparisons. The first method is to divide R&D by GDP, which results in indicators of ***relative effort*** vis-à-vis total economic activity. The second method is to convert all foreign-denominated expenditures to a single currency, which results in indicators of ***absolute*** effort. The first method is a straightforward calculation, but enables only gross national comparisons. The second permits finer inter-country comparisons, but first entails choosing an appropriate currency conversion series.

Since, for all practical purposes, there are no widely accepted R&D-specific exchange rates, the choice is between market exchange rates (MERs) and purchasing power parities. These are the only series consistently compiled and available for a large number of countries over an extended period of time.

At their best, MERs represent the relative value of currencies for goods and services that are traded across borders—that is, MERs measure a currency's relative international buying power. But because sizable portions of most countries' economies do not engage in international activity, and because major fluctuations in MERs greatly reduce their statistical utility,* an alternative currency conversion series—PPPs—has been developed (Ward 1985). PPPs take into account the cost differences across countries of buying a similar basket of goods and services in numerous expenditure categories, including nontradables: The PPP basket is representative of total gross domestic product across countries. When applied to current R&D expenditures of the nation's major competitors—Japan and Germany—the result is the same: PPPs result in a lower estimate of total research spending than do MERs, as shown in figure 4-5 (A).**

PPPs are the preferred international standard for calculating cross-country R&D comparisons and are used, for example, in all official OECD R&D tabulations. Although there is a considerable difference in what is included in GDP-based PPP items and R&D expenditure items, the major components of R&D costs—fixed assets and the wages of scientists, engineers, and support personnel—are more suitable to a domestic converter than to one based on foreign trade flows. Exchange rate movements bear little relationship to changes in the cost of domestically performed R&D.

This point is clearly displayed in figure 4-5 (B) and (C). When annual changes in Japan's and Germany's R&D expenditures are converted to U.S. dollars with PPPs, they move in tandem with such funding denominated in the home currencies. Changes in dollar-denominated R&D expenditures converted with market exchange rates exhibit wild fluctuations. MER calculations indicate that, between 1980 and 1990, German and Japanese R&D expenditures each increased in four individual years by 30 percent or more. In actuality, nominal R&D growth never exceeded 30 percent in either country during this period, and generally was in the range of 10 percent per year or less. Additionally, MER calculations would imply that Japan's R&D expenditures declined in 1982, as did Germany's in 1981, 1984, and 1989. Yet foreign-denominated R&D expenditures were positive in each of those years. The use of MERs here is obviously inappropriate: PPP calculations result in positive annual R&D expenditure changes considerably closer to the countries' actual funding patterns.

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*MERs are also vulnerable to a number of distortions—for example, currency speculation, political events such as wars or boycotts, and official currency intervention—that have little or nothing to do with changes in the relative prices of internationally traded goods.

**Japan's R&D in 1990 totaled $66 billion based on PPPs and $90 billion based on MERs. German R&D was $32 and $42 billion, respectively. U.S. R&D was $145 billion.

of these countries' performance totals. The industry R&D performance share grew most rapidly in Japan—rising from 57 percent of total in 1975 to 70 percent in 1991.[24] In most of the seven countries, the *academic sector* was the next largest R&D performer:[25] Only in France and Italy was government's R&D performance (which included that in several nonprivatized industries, as well as in some sizable government labs) larger than that of academia. Government's R&D performance share was smallest in Japan and the United States.

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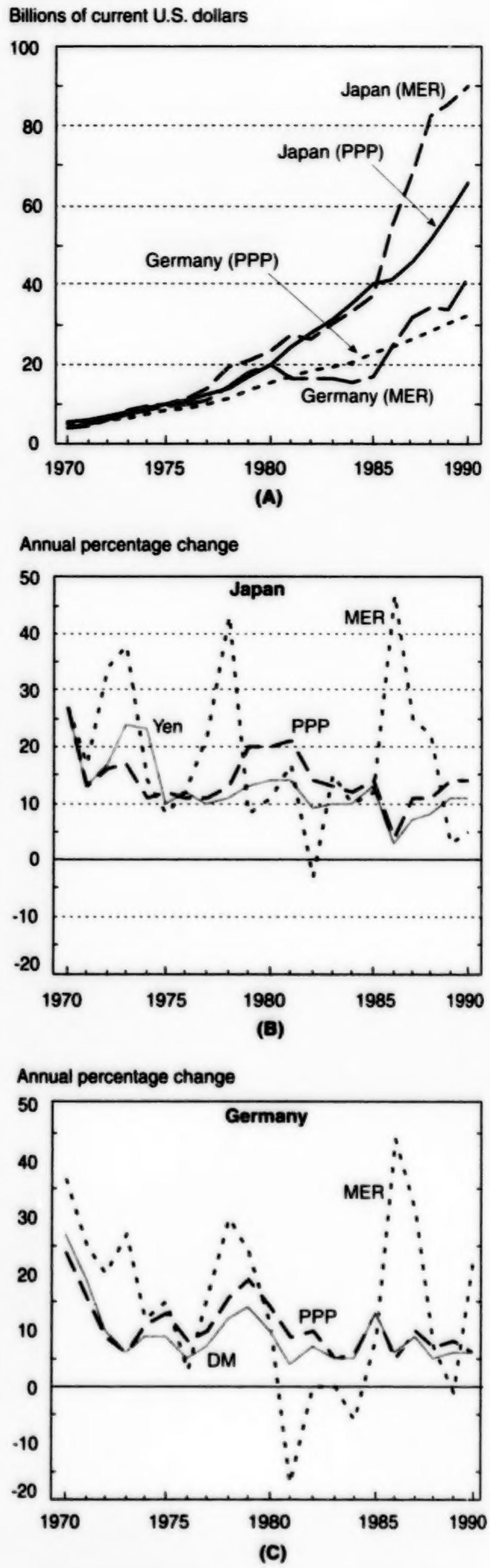
[24] Detailed and more extensive data can be found in SRS (1991).

[25] The national totals for Europe, Canada, and Japan include the research component of general university funds (GUF block grants) provided by all levels of government to the academic sector. Therefore, at least conceptually, the totals include both academia's separately budgeted research and that undertaken as part of universities' departmental R&D activities. In the United States, the Federal Government generally does not provide research support through a GUF equivalent, preferring instead to support specific separately budgeted R&D projects. (See footnote 34.) On the other hand, a fair amount of state government funding probably does support departmental research at public universities in the United States. Data on departmental research, which is considered an integral part of instructional programs, generally are not maintained by universities. U.S. totals may thus be underestimated relative to the R&D effort reported for other countries.

Figure 4-5.
Japanese and German R&D expenditures and annual changes in R&D, at market exchange rates and by PPPs



NOTES: German data are for the former West Germany only. MER = market exchange rate; PPP = purchasing power parity; DM = deutsche mark.

See appendix table 4-2. *Science & Engineering Indicators – 1993*

National governments and *industry* provide a dominant proportion of each country's respective R&D funding totals. Shares for these sectors, however, differed substantially from one country to the next. While government provided more than 40 percent of R&D funds in the United States, France, Italy, and Canada, it was the source of somewhat less funds in Germany (37 percent) and the United Kingdom (35 percent), and considerably less in Japan (19 percent). (See figure 4-6.) Industry provided a share of R&D funds roughly comparable to the government contribution in all countries except Japan and Germany. Private firms there funded 73 and 60 percent, respectively, of the national totals. Foreign funding—predominately from industry for R&D performed by industry—was an important funding source in several countries. (Trend data are provided in "Foreign R&D in the United States.") The funding share represented by funds from abroad ranged from 12 percent of the United Kingdom's R&D total to a mere 0.1 percent of Japan's total. In the United States, almost 6 percent of funds spent on R&D in 1990 came from majority-owned foreign firms investing domestically: This was up considerably from the 2-percent funding share provided by foreign firms in 1980. (See appendix table 4-37.)

Total and Nondefense R&D/GDP Ratios. R&D expenditures as a percentage of GDP have become one of the most widely used indicators of a country's commitment to scientific knowledge growth and technology development. France, Germany, Japan, the United Kingdom, and the United States each maintained an R&D/GDP ratio of between 2 and 3 percent throughout the 1980s. In 1991, the ratios for these countries were 2.4, 2.8, 3.0, 2.1, and 2.6 percent, respectively.[26] (In Italy and Canada, this ratio has changed from about 1 percent to 1.4 percent over the past 10 years.) For most of these countries, this measure of their economy's research intensity climbed rather rapidly from the mid-seventies through the mid-eighties before settling at their peak levels. Indeed, for several countries—including the United States, United Kingdom, and Germany—the R&D/GDP ratio has drifted downward since the late eighties. Even in Japan, which experienced the most rapid and unabated R&D growth during the past two decades, this ratio dropped slightly in 1991, from 3.1 percent in 1990 to 3.0 percent of total. Moreover, there are indications of a further R&D slowdown since then (Swinbanks 1993). With the exception of Germany, annual rates of R&D spending growth in all the countries since 1985 is less than those reported for the previous 5 years. (See appendix table 4-35.) Although cuts in defense R&D certainly were a contributing factor—particularly in the United States and United Kingdom—the main cause of the overall R&D spending slowdown in most of these industrialized countries was that industry-financed R&D stagnated, and in some cases even declined.

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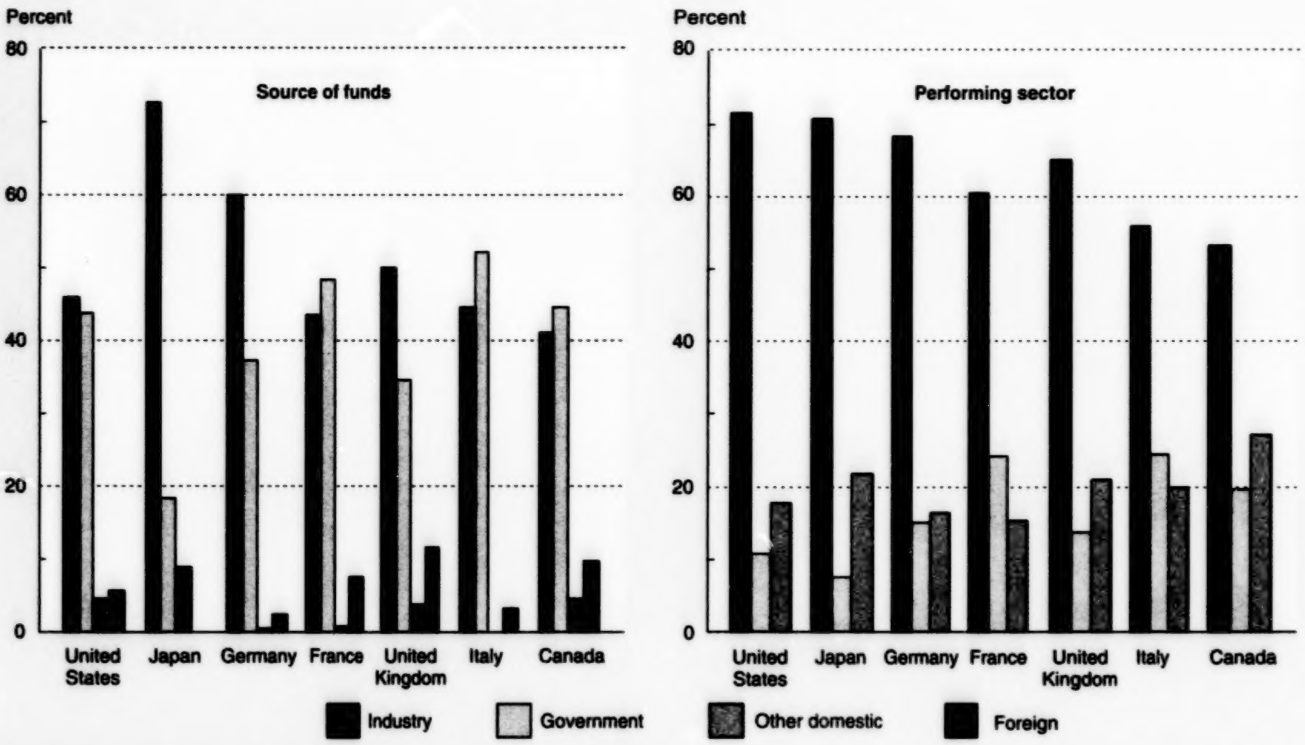
[26] The 1991 R&D/GDP ratio for unified Germany was 2.6 percent.

Figure 4-6.
R&D expenditures, by country, source, and performer: 1991



NOTES: German data are for the former West Germany only. Foreign performers are included in the "industry" and "other domestic" sectors.

See appendix tables 4-37 and 4-38.

Science & Engineering Indicators – 1993

The above comparisons are of trends in total R&D spending. Yet, with the end of the Cold War and the recent policy focus on economic competitiveness and commercialization of research results, probably a more relevant indicator of a nation's scientific and technological strength is the ratio of nondefense R&D expenditures to GDP. This is not to say that defense-related R&D does not benefit the commercial sector: There unquestionably have been technological spillovers from defense to the civilian sector. But almost as certainly, the benefits are less than if these same resources had been allocated directly to commercial R&D activities. Moreover, considerable anecdotal evidence indicates that the technological flow is now more commonly from commercial markets to defense applications, rather than the reverse.

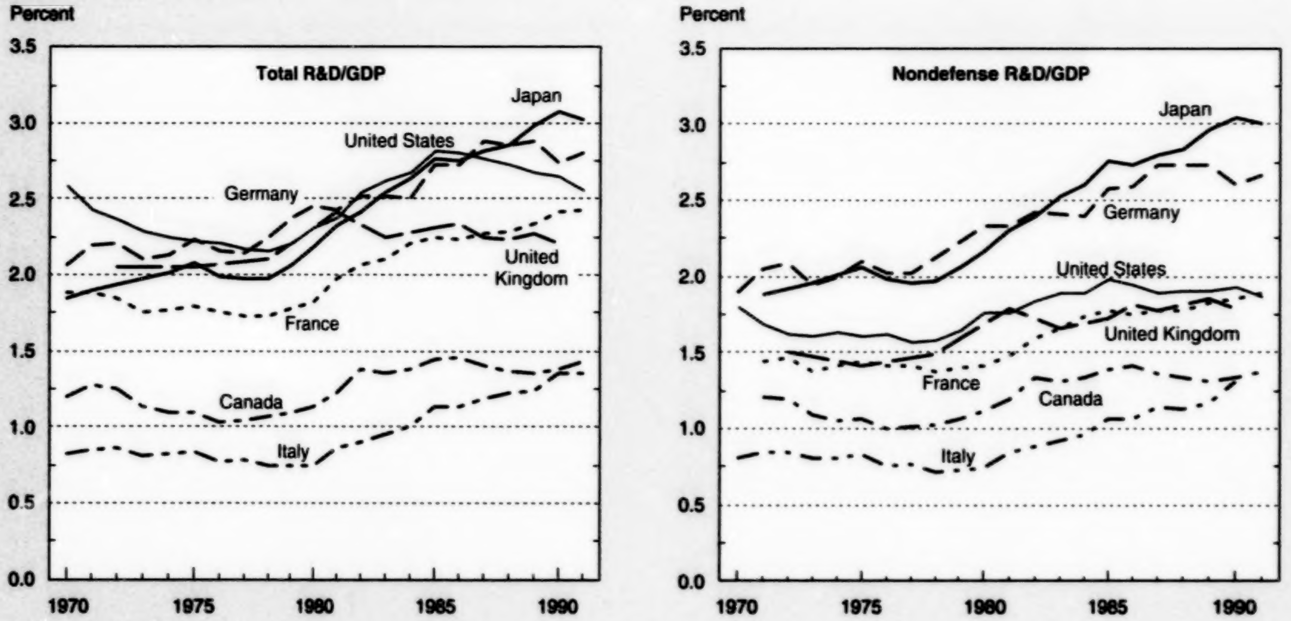
Intercountry comparisons of R&D expenditures change dramatically when defense-related expenditures are excluded. The nondefense R&D/GDP ratio in both Japan (3.0 percent) and Germany (2.7 percent) considerably exceeded that of the United States (1.9 percent) in 1991, and have done so for more than two decades. (See figure 4-7 and appendix table 4-36.) The nondefense R&D ratio of France matched that of the United States; those of the United Kingdom (1.7 percent), Canada (1.4 percent), and Italy (1.3 percent) were somewhat lower.

In absolute dollar terms, the U.S. international position was markedly different—and comparatively more favorable—than that indicated by the nondefense R&D/GDP ratios. Between 1980 and 1990, growth in U.S. nondefense R&D spending was rather similar to that in other industrial countries, save for Japan, whose nondefense R&D expenditure growth was notably faster than in the United States. Thus, as a percentage of the U.S. nondefense R&D total, comparable Japanese spending jumped from 44 percent in 1980 to 62 percent in 1990. (See figure 4-8.) Japanese nondefense R&D reached $59 billion (in constant 1987 dollars), compared with the $94 billion U.S. nondefense R&D total. Germany annually spent an amount equal to 28 to 30 percent of U.S. spending during the 10-year period, while France annually spent an amount equivalent to 16 to 17 percent of the U.S. nondefense R&D total. In 1989, the combined nondefense R&D spending in these three countries surpassed that in the United States; it is now higher still.

Federal Support for R&D

Federal support for the Nation's scientific and technological base is in a period of flux and re-examination. With the close of the Cold War and the arrival of a new administration, public debate has focused on how best to re-orient the federal effort away from traditional—

Figure 4-7.
R&D as a percentage of GDP, by country

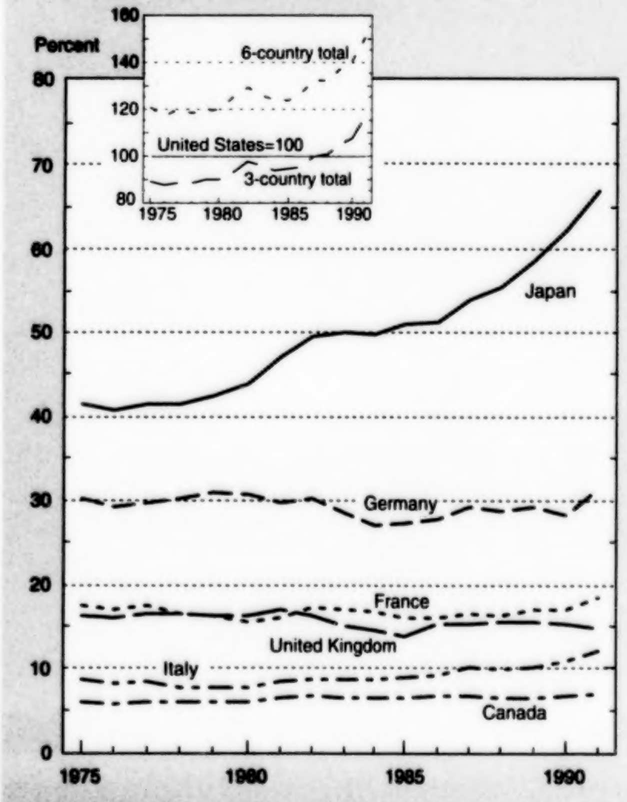


Note: German data are for the former West Germany only.

See appendix tables 4-35 and 4-36.

Science & Engineering Indicators – 1993

Figure 4-8.
Nondefense R&D: Foreign spending as a percentage of U.S. spending



NOTES: Three-country total is for Japan, Germany, and France. German data are for the former West Germany only.

See appendix table 4-36. *Science & Engineering Indicators – 1993*

primarily defense-related—S&T concerns and toward more commercial technology support. Although these are not new concepts, defense conversion, dual-use technology, technology transfer, and research partnering have become an integral part of the current R&D nomenclature to an extent that would have been unimaginable 10 years earlier. Federal decisions have a major impact on the Nation's military and commercial S&T base and on its global technological leadership. With the level of direct R&D federal funding now surpassing $70 billion annually, the specific purposes to which these funds are being applied, the mechanisms by which they are allocated, and the effectiveness of the projects they support are subjects of great interest.

This section examines the role and extent of direct federal R&D funding. It begins by defining aspects and patterns of that support—socioeconomic objectives, research disciplines, character of work, agency, performer (including federal labs), and the recent focus on federal interagency initiatives. Specific R&D funding issues that have major defense-related relevance are described, including trends in DOD's R&D expenditures and the government-wide program in support of defense conversions activities.

Federal Focus by National Objective

The Berlin Wall came down on September 11, 1989, and 2 years later—in December 1991—Communism in the former Soviet Union was replaced with dawning democracy. With these two events, the debate surrounding

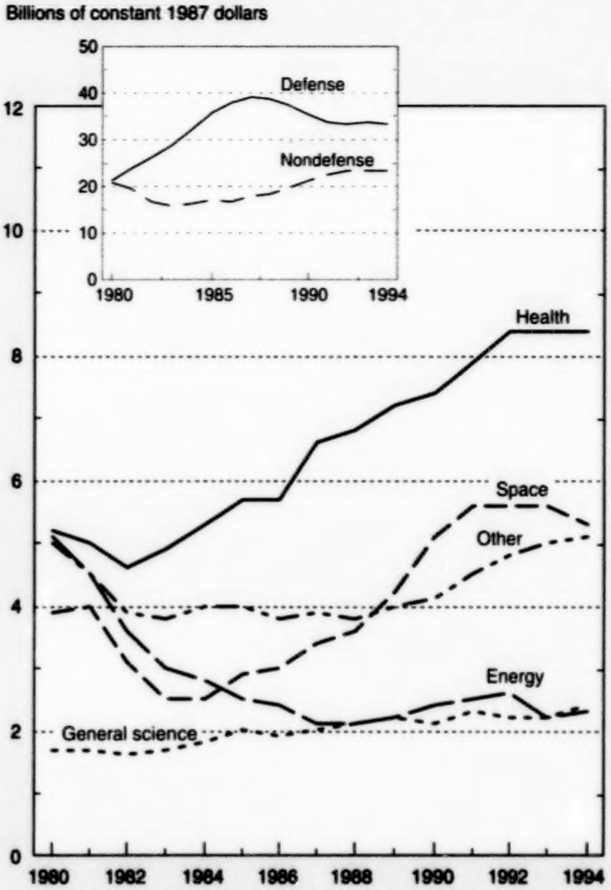
U.S. science and technology policy in the nineties was irreversibly redefined. The policy focus has since begun to shift from military technological superiority toward federal initiatives designed to help recapture global commercial primacy.[27] These changes in national policy objectives are mirrored by changes in the functional focus of federal R&D support, as indicated in federal spending documents.

Funding Trends. Federal R&D funding priorities shifted overwhelmingly toward defense programs in the 1980s; these included both Department of Defense programs and nuclear weapons research funded by the Department of Energy (DOE).[28] Defense R&D spending peaked in 1987 at $39 billion, when it accounted for 69 percent of the federal R&D total. The only other function to experience substantial inflation-adjusted R&D funding growth during the eighties was health, particularly the R&D programs of the Department of Health and Human Services (HHS). Funding for space, energy, and a variety of smaller R&D budgetary categories held constant at 1980 levels or was reduced. Funding for general science research inched upward.

In the late eighties, however, the data reflect a distinct de-emphasis on defense priorities and substantial growth in health research—much of it AIDS-related—and space research—primarily for Space Station Freedom.[29] Energy spending held fairly steady, although its emphasis shifted from nuclear technologies to coal research.

1994 Funding Patterns. The current administration has stated (Clinton and Gore 1993) its intent to shift the focus of federal R&D support back to an even military-civilian split by 1998. As of this writing, however, it has had the opportunity to submit only one budget proposal from which specific S&T priorities might be discerned.[30]

Figure 4-9.
Federal R&D funding, by budget function



NOTE: "Other" includes all nondefense functions not separately graphed, such as agriculture and transportation.

See appendix table 4-26. *Science & Engineering Indicators – 1993*

As shown in figure 4-9, national defense—including DOD and DOE funds—remains the single largest focus of the proposed 1994 federal R&D effort, accounting for 59 percent of total, as it did the 2 previous years. However, as was the case with 1993 funding, much of the DOD monies would be devoted to defensewide initiatives, including dual-use technologies (see "DOD Research, Development, Test, and Evaluation"). Similarly, within DOE's atomic energy defense budget, technology transfer activities from weapons labs to industry is one of the few growth areas.

The following five functions account for 91 percent of estimated 1994 R&D federal budget authority:

- ♦ national defense—59 percent, including DOD and DOE funds;
- ♦ health—15 percent, which is roughly comparable to the percentage of nonfederal R&D support that is health-related (see "Health: The Growing Focus of National R&D Support");
- ♦ space research—9 percent;
- ♦ general science—4 percent; and

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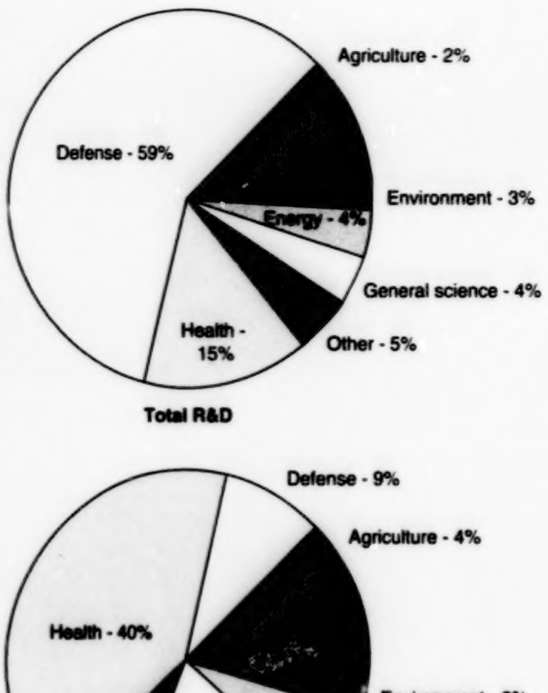
[27] Of course, the United States is not the only country for which the end of the Cold War introduced major changes in the national S&T landscape. Reunification has produced a host of problems and opportunities as East and West Germanys' S&T efforts are integrated into a single united German system, (Meyer-Krahmer 1992), and defense conversion issues are extremely important to the economic restructuring of the former Soviet Union (NAS 1993).

[28] The Office of Management and Budget classifies all activities within the federal budget into 20 functional categories. There are 16 "functions" that contain federal R&D programs. For definitions and details, see SRS (1993b). The administration recently announced its intention to group federal R&D expenditures data into 10 mutually exclusive categories that will assist in policy and budget decisionmaking. The Office of Science and Technology Policy and Office of Management and Budget have proposed grouping R&D data by their relevance to the following national S&T priority concerns: manufacturing, communications and information, natural resources and the environment, education and training, transportation, national security, energy supply and demand, food and fiber production, health, and a 10th category labeled "other R&D" that would include R&D activities not captured in the first nine categories.

[29] Funding for the Space Station rose from $22 million in 1984, the first year for which this program received a separate budget line item, to $1.75 billion in 1990. (See AAAS, annual reports.)

[30] The data reported here reflect estimates for R&D programs contained in the administration's 1994 budget proposal which was submitted to Congress in April 1993 (OMB 1993). The amounts do not reflect congressional authorization, appropriation, deferral, and apportionment actions that were completed after these data were collected.

Figure 4-10.
Federal R&D funds, by budget function: 1994



See appendix tables 4-26 and 4-27.
Science & Engineering Indicators – 1993

- energy—4 percent. (See figure 4-10.)

Two other functional areas of federal concern each account for 2 percent of R&D budget authority: (1) transportation and (2) natural resources and the environment. Environmental research, in particular, has been identified as an area of specific government interest that is likely to receive increased funding from the present administration.[31] The largest single percentage increase for 1994 was provided in the Commerce and Housing Credit function—jumping 75 percent over 1993—under which is included R&D support at the National Institute for Standards and Technology (NIST): The estimated $380 million NIST total comprises both its intramural research program and extramural Advanced Technology Program support for precompetitive generic technologies.

The functional distribution of basic research funding differs from that of the R&D total. In 1994, health is slated to receive the single largest share (40 percent) of the federal basic research total. General science—which here includes funding for the National Science Foundation (NSF) and for the research part of DOE's now canceled Superconducting Super Collider—accounts for 20 percent of estimated federal basic research authorizations. This proportion is down from the 24-percent share it received in 1980. National defense basic research accounts for about 9 percent of the 1994 basic research total—somewhat less than its 12-percent share in 1980.

International Comparisons.[32] Countries' relative shares of government R&D appropriations reflect marked differences in national priorities. In the United States, 59 percent of the 1992 federal R&D investment was devoted to national defense, compared to 46 percent in the United Kingdom, 37 percent in France, 11 percent in Germany, 7 percent each in Italy and Canada, and 6 percent in Japan. (See figure 4-12.) The U.S. Government also emphasizes health-related R&D (13 percent of total); this emphasis was especially notable in its R&D support for life sciences given to academic and similar institutions.[33]

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[31] Available statistics on such funding, however, tend not to capture the full extent of these environmentally-related R&D activities. Based on the programmatic budgetary classifications used in this section, $1.8 billion was slated for natural resources and the environment in fiscal year 1994. Official budget documents (OMB 1993)—not constrained by formal classification schemes—reported an environmental R&D investment of more than $3 billion in 1994, which included $1.5 billion for the U.S. Global Change Research Program. Using a comprehensive review of federal expenditures, Gramp, Teich, and Nelson (1992) identified a $4.5 billion portfolio for environmental R&D in fiscal year 1992, encompassing hundreds of programs at more than 20 agencies. The 1992 total is about 9 percent higher than the estimated $3.7 billion budgeted in 1990, and excludes an estimated $0.7 billion devoted to environmental health R&D, and $0.6 billion equally divided between space-related environmental sciences and administrative/overhead costs. For further discussion on this topic, see Carnegie Commission (1992a).

[32] Data on the socioeconomic objectives of R&D funding are rarely obtained by special surveys, but rather are generally extracted in some way from national budgets. Since these budgets already have their own methodology and terminology, these R&D funding data are subject to comparability constraints not placed on other types of international R&D data sets. Notably, although each country adheres to the same criteria for distributing their R&D by objective (as outlined in OECD 1981), the actual classification may differ among countries because of differences in the ***primary objective*** of the various funding agents. Note also that these data are of government R&D funds only, which account for widely divergent ***shares*** and ***absolute amounts*** of each country's R&D total. The classification of the U.S. totals presented here are generally consistent with those presented previously in this chapter.

[33] For detailed comparisons—by field of science—of government (national, state, and local) funding of (1) academic research (including for separately budgeted research and research supported out of general university funds) and (2) academically related research (such as that of university-administered FFRDCs and the National Institutes of Health intramural program) in the United States, United Kingdom, Netherlands, France, Germany, and Japan, see Irvine, Martin, and Isard (1990). For further comparisons with Canada and Australia, see Martin and Irvine (1992).

Indicators for 1987 show, for example, that all of these countries emphasized the life sciences in this government-supported research (31 percent or more of total), with the United States devoting a particularly large share (49 percent) of its academic and related support to this broad field. Relative to other countries, the emphasis in Japan was on engineering, and in France and Germany on physical sciences. Relatively high priority was accorded the environmental sciences in the United Kingdom, and the social sciences in Canada, the Netherlands, and Australia. See appendix table 4-46.

Japanese Government R&D appropriations in 1992 were invested relatively heavily (51 percent of total) in the "advancement of knowledge" (which is combined support for "advancement of research" and "general university funds," or GUF).[34] Energy-related activities accounted for 21 percent of governmental R&D funds, reflecting the country's concern with its high dependence on foreign sources of energy. In each of the four European countries and Canada, industrial development accounted for 8 percent or more of governmental R&D funding; it accounted for 4 percent of the Japanese total, but just 0.3 percent of U.S. R&D. The latter figure—which may be understated relative to other countries as a result of compilation differences—is likely to increase given the intention of the current administration to provide further investment in commercially relevant R&D programs—notably within NIST—that are classified under this socioeconomic category.

Structure of Federal R&D Obligation Support

Federal R&D funding patterns over the past decade clearly reflect changing government priorities. The following sections explore these patterns and priorities by providing summary information on federal R&D support by agency sponsor, character of work, scientific field of inquiry, mode of support, and category of performer, including that undertaken in government laboratories.[35]

Patterns of Federal Agency Support. Because most functional categories receive their R&D support from relatively few agencies, agency support patterns are similar to the distribution pattern of Government R&D support by functional objective. In 1994, the Federal Government will obligate (see "Definitions") an estimated $74 billion in support of R&D and related facilities. Although some 25 federal agencies contribute to this total, 95 percent of the funding is provided by just 6, as follows:

- DOD—51 percent,
- HHS—15 percent,
- National Aeronautics and Space Administration (NASA)—13 percent,
- DOE—11 percent,
- NSF—3 percent, and
- Department of Agriculture (USDA)—2 percent.

Since 1981, DOD has provided more R&D funds annually (for both in-house and external research) than all other agencies combined. (See figure 4-13.) This dominance in DOD's funding share peaked in 1986 at 64 percent of total.

At $11 billion in 1994, the health programs of HHS—particularly its National Institutes of Health (NIH) which recently absorbed the annual $1 billion R&D functions of the Alcohol, Drug Abuse, and Mental Health Administration—accounts for the second largest share of all federal R&D funding.[36] HHS is also the source of roughly 40 percent of federal basic research funds disbursed nationwide, most of which are slated for research in the life sciences. (See appendix table 4-15.) Between 1986 and 1994, total R&D obligations by HHS grew $5 billion, or 46 percent in constant dollars.[37] NASA's recent R&D budget has also climbed significantly. Like that of HHS, it was up $5 billion, or 95 percent in constant dollars during the 1986-94 period. One-fifth of NASA's estimated 1994 R&D budget is planned for Space Station Freedom (SRS 1993b).

Among the other nondefense agencies, the Department of Commerce and the National Science Foundation have also experienced relatively fast research growth during the past several years. Between 1990 and 1994, inflation-adjusted R&D obligations grew by an estimated 49 percent for Commerce—primarily for industry-related applied research support—and by 26 percent for NSF, especially for university-performed basic research. In terms of their ***absolute*** funding levels, the amount of R&D support from these two agencies (a combined $3 billion) pales when compared with those of the top four federal funders.

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[34] In the United States, "advancement of knowledge" is a budgetary category for research unrelated to a specific national objective. Furthermore, whereas general university funds are reported separately for Japan and European countries, the United States does not have an equivalent GUF category: Funds to the university sector are distributed among the objectives of the federal agencies that provide the R&D funds.

The treatment of GUF is one of the major areas of difficulty in making international R&D comparisons. In many countries other than the United States, ***national*** governments support academic research primarily through large block grants that are used—at the discretion of each individual higher education institution—to cover administrative, teaching, and research costs. Only the R&D component of these general university funds are included in national R&D statistics, but problems arise in identifying (1) how much the R&D component is, (2) the funding source (i.e., the government sector or higher education's own funds); and (3) the objective of the research.

Government GUF support is in addition to that which is provided in the form of earmarked, directed, or project-specific grants and contracts (and thereby can be assigned to specific socioeconomic categories). In the United States, the Federal Government (although not necessarily state governments) is much more directly involved in choosing which academic research projects are supported than in Europe and elsewhere. Thus, these socioeconomic data are indicative not only of relative international funding priorities, but also of funding mechanisms. For 1992, the GUF portion of total national governmental R&D support was between 35 and 43 percent in Japan, Italy, and Germany; about 20 percent in the United Kingdom and Canada; and 12 percent in France.

[35] See OTA (1991) and CBO (1991) for a review of issues related to federal research support.

[36] AIDS research accounts for $1.3 billion, or 12 percent, of the 1994 HHS R&D funding total.

[37] Health-related research costs, however, have risen considerable faster than would be indicated by the GDP implicit price deflator. When HHS R&D expenditures are deflated with the BRDPI (see "Health: The Growing Focus of National R&D Support"), the estimated increase from 1986 to 1994 is one-fourth less (or 34 percent) than that calculated using the GDP deflator.

Health: The Growing Focus of National R&D Support

Congress and the administration are paying considerable attention to issues related to the Nation's health care system; research is an important component of overall health costs. Although it would be difficult to distribute the national R&D total among specific categories of national objectives, this section attempts to provide a perspective on federal and nonfederal R&D trends for health-related investments.

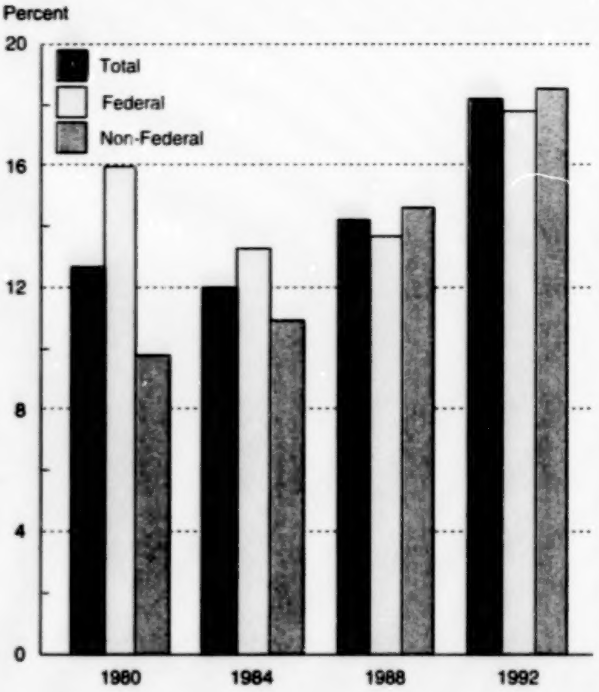
The National Institutes of Health (NIH) annually provides expenditure data on the source and performance of the Nation's health R&D. These tabulations are more comprehensive than the Office of Management and Budget function data presented elsewhere, because NIH attempts to include

- health-related components of all agencies' R&D in these totals, irrespective of their formal budget function classification;
- expenditures from nonfederal government sources; and
- health R&D from private nonfederal sources—primarily industry, but also private nonprofit organizations such as the Howard Hughes Medical Institute.

According to NIH (1992), sources of nonfederal health R&D support grew considerably faster than did federal sources during the eighties. Public sector financing accounted for roughly two-thirds of the total health-related R&D in 1980; of this, about 90 percent was funded by the federal sector, and the rest was funded by state and local governments. Approximately one-third of the national health R&D total derived from private sources. (See appendix table 4-28.) Overall, about 13 percent of the Nation's R&D expenditures were health-related: 16 percent of federal R&D was for health as was 10 percent of the nonfederal total.

By 1992, government's share of the estimated $28 billion spent on health R&D had fallen to less than half: Only 41 percent of total health R&D support came from the Federal Government—mostly NIH—and 6 percent from the states and localities. This decline in the federal *share* was in spite of a 24-percent increase in the constant dollar support *level* over the same 12-year period.* Private sector support, led by the R&D investments of drug and biotechnology companies, grew by almost 170 percent between 1980 and 1992. As a result of these growth trends, a remarkable 18 percent of the national R&D investment was related to health in 1992; comparable percentage shares of federal and nonfederal funding totals were devoted to such purposes. (See figure 4-11.)

Figure 4-11.
Funding of health R&D as a percentage of total R&D, by source



See appendix tables 4-4 and 4-28.

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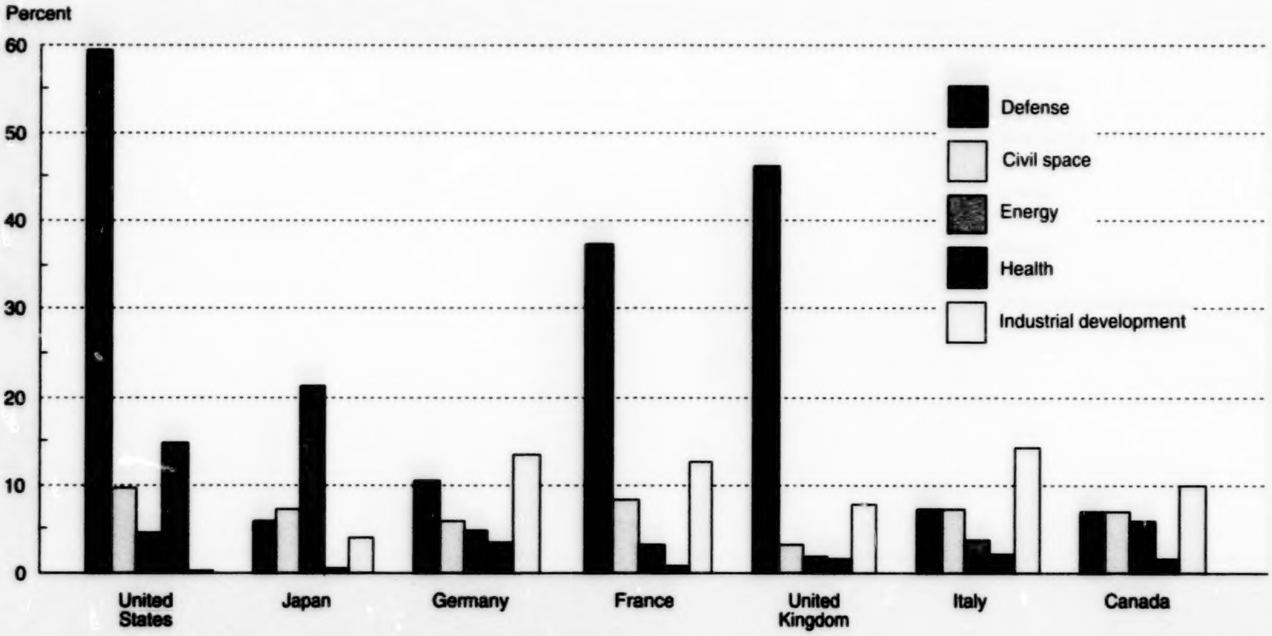
*Constant dollar estimates are based on the Bureau of Economic Analysis/NIH biomedical research and development price index (BRDPI). Since the BRDPI is designed to reflect price movements in biomedical R&D, it measures real changes in health R&D expenditures better than does the broader GDP deflator (Schuttinga 1993). Between 1980 and 1990, there was a 69-percent increase in the GDP deflator. (See appendix tables 4-1 and 4-28.) During this same period, health-related research costs—as measured by the BRDPI—rose by 98 percent. Jankowski (1993) estimates that of the 12 industries for which an R&D price index was calculated, the chemicals industry (which includes drugs and medicines) experienced the most rapid increase in R&D costs during the eighties.

DOD emphasizes programs in their development stage: Relatively little DOD funding is provided for basic or applied research. Aggregate funding by all other federal agencies is more evenly distributed among the three R&D categories (about 30 percent of total for each) and R&D plant projects (10 percent of total). (See figure 4-14.)

R&D Agency-Performer Patterns. Over the years, one or two federal funding agencies have come to provide the bulk of R&D support to each of the different types of R&D performers. For example, federal R&D obligations to FFRDCs are dominated by funding from DOE and DOD, and the largest shares of R&D funds for

Figure 4-12.
Government R&D support, by country and socioeconomic objective: 1992



NOTES: German data are for the former West Germany only. Detail do not add to 100% because funding for some objectives (for example, advancement of knowledge) is not graphed. R&D is classified according to its *primary* government objective, although it may support any number of complementary goals. For example, defense R&D with commercial spin-offs is classified as supporting defense, not industrial development.

See appendix table 4-39. *Science & Engineering Indicators – 1993*

academic and other nonprofit performers originate in HHS. (See text table 4-3.) Similarly, DOD, NASA, and DOE sponsor applied research within industrial firms and FFRDCs administered by either universities, industry, or nonprofit institutions. In contrast, nonprofit institutes and the research hospitals of the academic sector receive the bulk of their applied research and development funds from NIH.

The largest recipient of basic research funds (in terms of estimated 1993 total agency obligations) is universities and colleges; this sector is primarily funded by HHS (50 percent) and NSF (24 percent). DOE, as in its support of applied research and development, is the largest provider of basic research funds to FFRDCs under contract with universities. Federal obligations for basic research in private firms are concentrated (56 percent) in NASA's research budget. Federal in-house work on basic research programs is distributed among at least six major agencies, with the largest portions conducted by NIH and NASA laboratories. Smaller portions are performed by the Department of the Interior's Geological Survey and USDA's Agricultural Research Service. (See appendix table 4-13 and "Patterns of Federal Lab R&D Performance.")

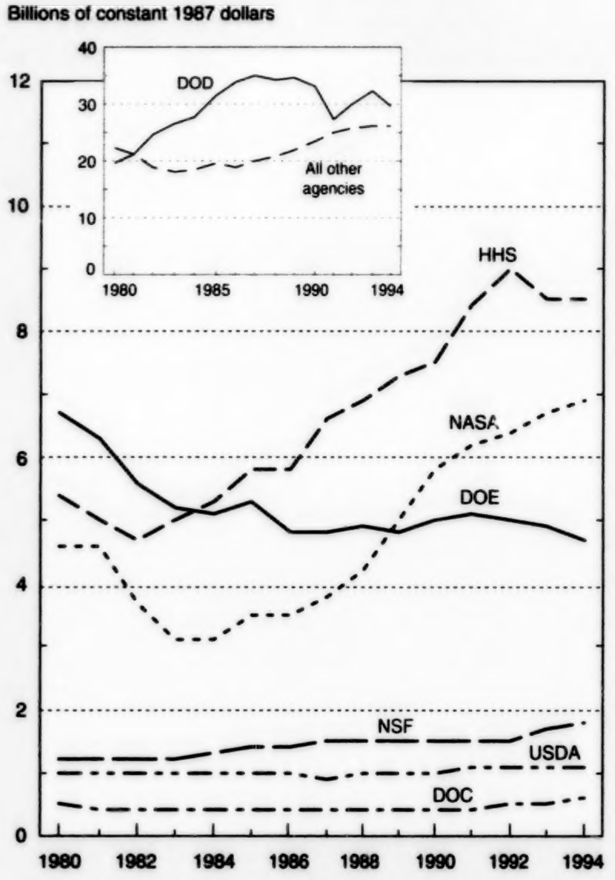
Trends in Character of Work Funding. While there are distinct and stable patterns in agency-performer R&D funding trends, notable shifts of relative growth and decline are apparent in the federal character of work R&D funding data. As a share of the R&D total, development obligations grew from 61 percent in 1980 to 68 percent in 1987—or 40 percent in constant 1987 dollars—mainly because of growth in defense-related R&D, which is 90 percent development. Since then, the development share has settled back to 61 percent of total, and inflation-adjusted obligations have declined by 9 percent. (See appendix table 4-10.)

Applied research fell from 23 percent of total in 1980 to 16 percent in the late eighties; this decline reflected the administration's policy that private industry can respond to nongovernmental market needs better than can the Federal Government in making civilian applied R&D investment decisions. More recently, applied (mostly nondefense) research has climbed back to a 20-percent share.

Throughout the 1980-93 period, federal basic research support has edged upward, from about 15 percent of R&D total in the early eighties to about 20 percent of total in the early nineties. This strong and sustained growth exemplifies the widespread governmental view of basic research as essential to the Nation's scientific, technological, and socioeconomic future.

Fields of Science and Engineering Research. Among fields receiving federal research support, life sciences garner the largest share of both basic and applied

Figure 4-13.
Federal R&D obligations, by selected agency



See appendix table 4-10. *Science & Engineering Indicators – 1993*

research obligations. Funding for the life sciences dominates ***basic research*** totals and has grown steadily since the early eighties. (See figure 4-15. Appendix table 4-46 and footnote 33 provide related international comparison data.) In 1980, the life sciences—including the biological, medical, and agricultural subfields—accounted for 31 percent of all federal basic research support. By 1993, they accounted for 46 percent ($6.6 billion) of the federal total ($14.2 billion). This growth—especially in the biological sciences—reflects the mission interests of NIH, the major funding agency for life sciences. DOE provides most funding for basic research in the physical sciences, which also has experienced steady growth over the past decade and now accounts for a 23-percent ($3.2 billion) basic research share.

The total amounts obligated for *applied research* in federal agency 1993 budgets were slightly below—3 percent—those estimated for basic research; these proportions have remained fairly stable since 1987. (See appendix tables 4-15 and 4-16.) Life sciences again received the largest applied research funding support, just surpassing engineering in terms of percentage share: 34 percent versus 33 percent, respectively, in 1993. Applied research funding for engineering—led by NASA's support for aeronautical engineering—has risen rapidly since 1990. Applied research funding for the physical sciences also gained ground in the early nineties, reversing 7 years of inflation-adjusted decline. (See figure 4-15.)

Academic Research Funding.[38] The combined federal basic and applied research investment reached an estimated $28 billion in fiscal year 1993. A large fraction of it—37 percent, including one-half of the basic research total and one-fourth of the applied research total—was carried out in the Nation's universities and colleges. This funding has been broadly justified in terms of its contribution to the

- mission interests of federal agencies (for example, defense and health);
- economic and commercial prosperity of the Nation;
- education and training of future scientists and engineers; and
- pursuit of knowledge for its own sake.

The structure of this $28 billion in federal research support is quite complex. Support is spread across many performers and a variety of disciplines, is directed toward various funding purposes, and is disbursed through diverse funding mechanisms. Data for addressing some of these complexities have long been collected (and covered in *Indicators*); to address some of the other structural aspects for which data have *not* been systematically collected, a special survey (OSTP 1992) was recently undertaken. This survey reviewed academic research funding during the eighties from six major civilian agencies; it found several distinctive patterns in the structure of this support.[39]

Between 1980 and 1989, federal funding—in constant dollars—has increased for all ***modes of support*** (individual investigator, research team, research center, major facility), but at different rates for each. The share of research funds going to individual investigators declined from 56 to 51 percent over the decade (see figure 4-16); in contrast, increases in shares were evident for research teams and major facilities. Changes differed across agencies and disciplines. For example, NIH provided increased funding for interdisciplinary research, with the result of stimulating awards to research teams. And, while the percentage of NSF research funding for centers

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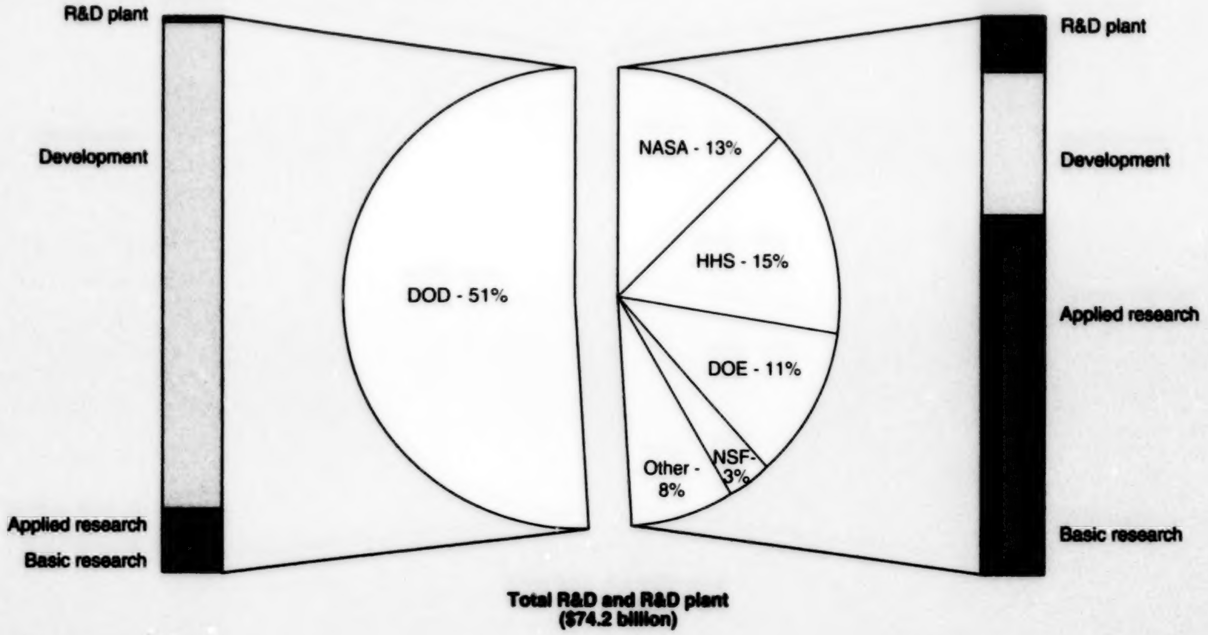
[38] See chapter 5 for more detailed information on federal academic research expenditures, including that in support of universities indirect costs.

[39] The six agencies studied were USDA, DOE, NASA, NSF, NIH, and the Environmental Protection Agency. DOD also participated in the study, but was unable to provide the specialized data requests for years other than 1989. The six civilian agencies accounted for more than 95 percent of the academic research funded by non-DOD agencies. The report also contains considerable funding detail on research at federal laboratories—including both intramural labs operated by agencies themselves and FFRDCs operated by outside contractors.

Figure 4-14.
Federal obligations, by agency and type of activity: 1994



See appendix table 4-10.

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rose from 3 percent in 1980 to 8 percent in 1989, trends in other agencies' mode of support was quite the opposite. Centers' share of the other five civilian agencies' combined academic research total fell slightly, from 16 to 14 percent.

In terms of *funding purpose*, shares for thematic research—the category that receives the bulk of federal academic support—declined slightly, dropping from 57 percent in 1980 to 56 percent in 1989. Meanwhile, the funding share for instrumentation increased from 1 percent of total in 1980 to 3 percent in 1989. The funding shares for disciplinary support and developing human resources remained level at 33 and 8 percent, respectively, of total.

In short, the report found that while there were definite changes in the structure of federal research during the eighties, these changes may not have been as dramatic as some had thought. On the other hand, the report's data extend only to 1989. In light of recent shifts in federal policy—for example, the increasing emphasis on thematic research in federal agency research budgets discussed in "Cross-Cutting R&D Initiatives," below—some of the trends identified for the eighties may be different in the nineties.

Cross-Cutting R&D Initiatives

Several years ago, the Federal Government chose to revitalize government-wide participation in S&T activities through the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). Chaired by the Director of the Office of Science and Technology Policy and with membership comprising the heads of almost all federal research-funding agencies, FCCSET is a mechanism through which the administration plans, budgets for, and coordinates research programs that are not limited by boundaries of agencies or disciplines (that is, "cross-cutting" programs). The FCCSET cross-cuts may well represent a major component of a shifting science policy paradigm (Brown 1992).

The Clinton administration, stating its intention to strengthen the FCCSET process, included funding for six presidential initiatives in its initial 1994 budget proposal. Identified as integral parts of an overall strategy to use science and technology to achieve national goals, combined funding for the six interagency initiatives equaled $12.5 billion—the equivalent of about one-sixth of estimated 1994 federal R&D support (OSTP 1993).[40] The six cross-cuts are

- biotechnology research, funded at $4.3 billion;
- advanced materials and processing, at $2.1 billion;
- global environmental change research, at $1.5 billion;
- advanced manufacturing technology, at $1.4 billion;
- high-performance computing and communications, at $1.0 billion; and

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[40] Precise comparison of the FCCSET initiatives and the federal R&D total is difficult because (1) definitions for the two sets of data are not necessarily identical, and (2) some double counting may occur for closely related activities that are present in more than one initiative.

Text table 4–3.
Estimated federal R&D obligations, by agency and performer: FY 1993

Performer	Performer total federal obligations	Primary funding source		Secondary funding source	
	—Millions of dollars—	—Percent—		—Percent—	
Total R&D	69,754	DOD	52	HHS	16
Federal intramural laboratories	16,643	DOD	50	NASA	16
Industrial firms	31,203	DOD	79	NASA	14
Industry-administered FFRDCs	2,142	DOE	82	DOD	15
Universities and colleges	11,764	HHS	53	NSF	16
University-administered FFRDCs	3,703	DOE	59	NASA	20
Other nonprofit institutions	2,957	HHS	58	DOD	9
Nonprofit-administered FFRDCs	721	DOD	62	DOE	30
Basic research	14,184	HHS	41	NSF	15
Federal intramural laboratories	2,893	HHS	38	NASA	21
Industrial firms	1,104	NASA	56	HHS	19
Industry-administered FFRDCs	227	DOE	95	HHS	5
Universities and colleges	7,070	HHS	50	NSF	24
University-administered FFRDCs	1,468	DOE	66	NASA	23
Other nonprofit institutions	1,228	HHS	71	NSF	11
Nonprofit-administered FFRDCs	79	DOE	86	DOD	11
Applied research	13,715	HHS	25	DOD	25
Federal intramural laboratories	4,948	DOD	28	NASA	18
Industrial firms	2,955	DOD	47	NASA	29
Industry-administered FFRDCs	451	DOE	83	DOD	5
Universities and colleges	3,183	HHS	58	DOD	14
University-administered FFRDCs	916	DOE	75	NASA	16
Other nonprofit institutions	976	HHS	54	AID	24
Nonprofit-administered FFRDCs	101	DOE	61	HHS	14
Development	41,855	DOD	76	NASA	11
Federal intramural laboratories	8,802	DOD	74	NASA	13
Industrial firms	27,144	DOD	85	NASA	10
Industry-administered FFRDCs	1,464	DOE	80	DOD	20
Universities and colleges	1,511	HHS	60	DOD	28
University-administered FFRDCs	1,318	DOE	42	DOD	37
Other nonprofit institutions	753	HHS	43	DOD	28
Nonprofit-administered FFRDCs	541	DOD	81	DOE	16

AID = Agency for International Development
DOD = Department of Defense
DOE = Department of Energy
FFRDC = federally funded research and development center
HHS = Department of Health and Human Services
NASA = National Aeronautics and Space Administration
NSF = National Science Foundation

See appendix table 4–11.

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- science, mathematics, engineering, and technology education, at $2.3 billion, although this FCCSET initiative is not directly included in an R&D budget.[41]

Multiple agency funding is a hallmark of the cross-cuts; for most initiatives, however, one or two agencies provide the bulk of the monies. (See figure 4-17.) For example, the largest initiative is for biotechnology for which more than three-quarters of its budget is controlled by NIH whose interests lie primarily in health-related programs. Almost 70 percent of global change research monies come from NASA and includes funding for its Earth Observing System program which is designed to address issues such as the greenhouse effect, ozone depletion, and deforestation. DOD is the primary or secondary funding agency for four of the initiatives in 1994: Only in the biotechnology and global change cross-cuts does DOD *not* play a major funding role.

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[41] President Clinton announced in August 1993 his intention to modify support for these six FCCSET initiatives. The biotechnology initiative is to be eliminated; the advanced materials and processing and advanced manufacturing technology initiatives are to be combined. In November 1993, the president established a new cabinet-level National Science and Technology Council to replace FCCSET, the National Space Council, and the National Critical Materials Council.

Patterns in Federal Lab R&D Performance*

The role of federal lab activity in the Nation's S&T enterprise has attracted considerable attention of late, especially in the context of debates on making federal labs' R&D programs more commercially relevant. (See "Technology Transfer and Commercialization.") Out of a total federal $70 billion R&D investment in 1993, laboratories owned or principally funded by the Federal Government received one-third ($23.2 billion). Intramural laboratories owned by the government and operated by agency personnel (government-owned, government-operated) accounted for 72 percent ($16.6 billion) of the federal lab total; FFRDCs (including both government-owned, contractor-operated labs, and labs owned by nongovernment organizations but which do virtually all of their work for government) accounted for 28 percent ($6.6 billion). (See text table 4-4.)

Three agencies account for almost 80 percent of the 1993 intramural lab effort: DOD labs performed half of this federal total;** about 15 percent each was undertaken in NASA and HHS (primarily NIH) labs. Three agencies also account for most (95 percent) FFRDC support. DOD and DOE provide most of the funding for FFRDCs administered by firms and nonprofit organizations: These two agencies, along with NASA, provide most of the university-administered FFRDC R&D funds. This high concentration in the federal labs R&D effort has been maintained over time. (For longitudinal data on intramural R&D, see appendix table 4-13; on FFRDCs, see appendix table 4-14.)

About half the money going to all federal labs is for nondefense programs. Nondefense lab performance includes funding for several agencies with a long track record in cooperating with private industry. For example, NASA devotes about 10 percent of its R&D to aeronautics research (SRS 1993b), which by statute is closely aligned to the interests of the commercial aircraft industry. Approximately 40 percent of the NIH research budget is applied and supports programs of interest to the pharmaceutical and biotechnology industries (OTA 1993). Moreover—as is borne out by technology transfer metrics (see "Technology Transfer and Commercialization")—USDA labs have long undertaken research programs of interest to private agriculture, and the central mission of the growing NIST labs' budgets is to serve industry needs.

The remaining half of the federal total is for defense labs, including much of the R&D in DOE's national weapons laboratories—Sandia, Lawrence Livermore, and Los Alamos. It is these labs that are facing the challenge to find alternative activities in light of expected reductions in defense R&D support. Up until recently, DOD and DOE labs have focused R&D efforts on their defense missions. Little attention was given to technology transfer activities. However, with no new nuclear weapons now planned and with the defense drawdown continuing, defense labs have turned increasingly toward nondefense research subjects including environmental technologies and the development of new products for industry. Indeed, technology transfer is now identified as a core mission activity of the Department of Energy. Systematically compiled data on defense/nondefense resources allocations, however, are not easily obtained.

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*Comprehensive coverage of issues related to federal laboratories—particularly to DOE's multi-program nuclear weapons laboratories—in the post-Cold War environment may be found in OTA (1993), in which ideas for this section originated. See also Davey (1992) for information on DOD FFRDCS, and Sanders (1993) for a concise historical perspective on current FFRDC issues.

**There is some confusion as to the actual level of DOD's intramural R&D effort. The NSF numbers reported here are defined to include only funds for in-house activities, yet OTA (1993) reports that over half of this money is passed through to outside defense contractors. The basis for this conclusion is DOD (undated) self-reports, stating that only $4.0 billion of total $8.5 billion laboratory research, development, test, and evaluation program funds are used for in-house activities.

FCCSET's impact on the budget process may extend beyond the numbers just presented. In light of crosscuts' new-found importance in framing R&D budget proposals, agencies commonly have rushed to highlight current research budgets and proposed increases in terms of their relevance to FCCSET activities. Many of these programs undoubtedly would be undertaken even without the FCCSET coordinating mechanism.

Defense-Related Issues

The magnitude and importance of defense R&D in the Nation's S&T enterprise is currently being transformed. Specifically, the recent changes in U.S. international security concerns have resulted in a pressing need to reduce or redirect the massive R&D investment in financial, human, and capital resources devoted to the defense industry for the past 40 years. This section discusses significant shifts in the funding components that comprise the DOD R&D budget, and summarizes the recently established federal technology conversion program.[42]

DOD Research, Development, Test, and Evaluation. There have been substantial changes in U.S. military strategy during the past several years: The focus has shifted from threat of global conflict with a known superpower adversary to greater concern with regional

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[42] For an indepth discussion of the role of defense in the changing S&T environment, see Alic et al. 1992.

Text table 4-4.
Estimated federal R&D obligations, by selected agency and government laboratory: FY 1993

Agency	Total R&D	Federal labs[1]	Intramural	FFRDCs
	Millions of dollars			
Total, all agencies	69,754	23,209	16,643	6,566
Department of Agriculture	1,337	899	899	*
Agricultural Research Service	654	625	625	0
Forest Service	177	161	161	0
Department of Commerce	622	477	477	*
National Institute of Standards & Technology	231	159	159	0
National Oceanic & Atmospheric Administration	379	307	307	0
Department of Defense	36,155	9,597	8,277	1,320
Department of the Air Force	12,652	1,416	1,148	268
Department of the Army	5,737	2,263	2,096	167
Department of the Navy	8,754	3,248	3,024	223
Defense agencies	8,397	2,337	1,690	647
Department of Energy[2]	6,731	4,745	567	4,178
Department of Health & Human Services	11,143	2,443	2,361	82
National Institutes of Health	10,568	2,242	2,163	79
Department of the Interior	541	482	482	*
U.S. Geological Survey	326	299	299	0
National Aeronautics & Space Administration	8,629	3,397	2,646	751

* = less than $500,000; FFRDC = Federally funded research and development center.

[1] Total for federal labs is the sum of intramural labs plus FFRDCs.

[2] Roughly 40 percent of the Department of Energy's R&D support to FFRDCs is provided to its three weapons labs: Sandia, Lawrence Livermore, and Los Alamos National Laboratories.

SOURCE: Science Resources Studies Division, National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993* (Washington, DC: NSF, 1993).

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contingencies. The process of crafting a post-Cold War defense—a process that began in 1989 after the dismantling of the Berlin Wall and the subsequent collapse of Soviet Communism—culminated in the formal elaboration of a new defense strategy released in May 1992 (Cheney 1993). Not surprisingly, elements of this strategy have major implications for the funding of DOD's research, development, test, and evaluation (RDT&E) activities.

From 1980 to the present, funding for RDT&E has grown consistently—if not smoothly—as a percentage of DOD's total budget: The RDT&E component rose from 10 percent of total in 1980 ($13 billion of the $132 billion DOD military outlay) to an estimated 14 percent in 1994 ($38 billion of the $269 billion total). In 1990, RDT&E accounted for 13 percent ($37 billion of the $291 billion) of DOD's military outlays. This growth demonstrates that R&D funding has been a critical component of the defense strategy throughout the period. (See appendix table 4-18.) In contrast to this positive funding trend, growth in other DOD functions has not been so stable. For example, funding for procurement of weapons systems rose considerably in the early eighties, from 22 percent of total in 1980 to 30 percent in 1987. Since then, procurements—out of which R&D in addition to the RDT&E budget is funded (see "Independent Research and Development")—have fallen both as a percentage of total (estimated at 23 percent of 1994 funds) and in absolute levels. (See appendix table 4-18.)

Within the RDT&E budget, funding for specific mission categories also has received shifting preferential treatment during the past 15 years.[43] Percentage share funding for DOD's strategic and tactical programs are almost a mirror image of one another. (See figure 4-18.) These trends reflect, initially, growth in the Air Force's major strategic missile systems such as M-X and Trident II, and—subsequently—a shift in support toward tactical weapons for theatre warfare servicing each of the three military branches. Funding for DOD's technology base fell considerably as a share of total—from 17 percent in 1980 to 9 percent in 1990—even though the actual dollars spent for this research category inched up each year. Substantial growth in the

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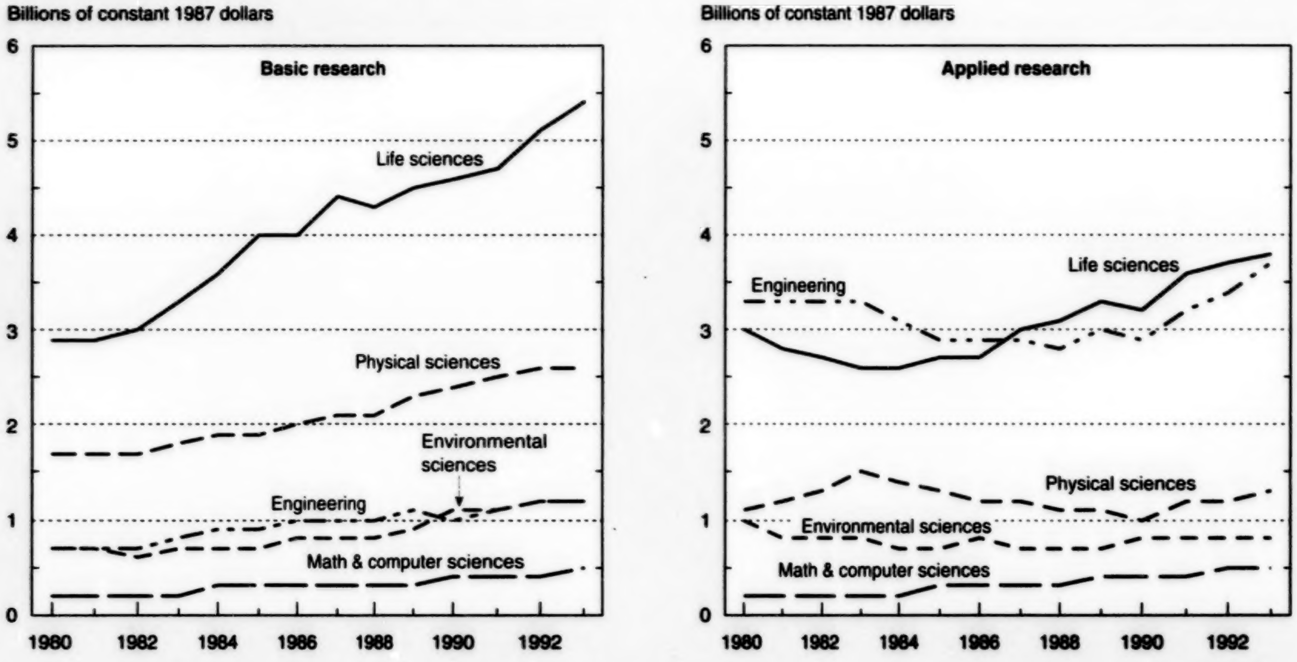
[43] DOD's technology base consists of all basic and applied research expenditures (6.1 fundamental research and 6.2 exploratory development monies, in DOD's nomenclature). The rest is what NSF calls "development," including funds for strategic and tactical programs, as well as for the somewhat generic nonsystems "advanced technology development" work (6.3A in the DOD vernacular). For fuller coverage of these definition issues, see CRS (1986). For considerably greater detail on DOD's fiscal year 1994 budget, see DOD (1993).

Figure 4-15.
Federal obligations for research, by field



See appendix tables 4-15 and 4-16.

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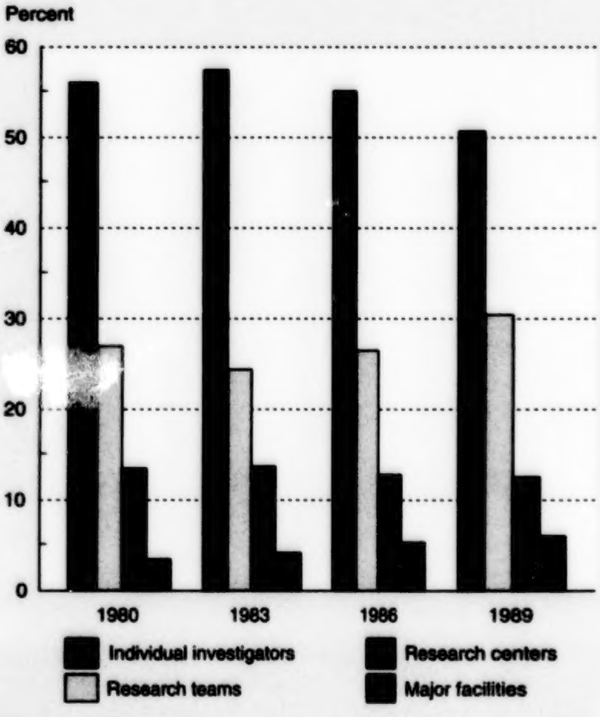
Figure 4-16.
Federal nondefense research funding to universities, by mode of research support



See appendix table 4-20. *Science & Engineering Indicators – 1993*

advanced technology development component during the mid-eighties primarily reflects the funding fortunes of Star Wars, the Strategic Defense Initiative's crash program for the deployment of space-based weapons.[44]

More recently, development funding for advanced technologies and funding for the technology base have been formally incorporated into the strategic plan underlying DOD's Science and Technology Program.[45] The guiding principle around which the program is organized is that technological superiority is a key element of deterrence in peacetime and provides a wide spectrum of military options in times of crisis. The new S&T program thus heavily emphasizes government-supported R&D in order to maintain the Nation's defense technology base. The military departments and defense agencies

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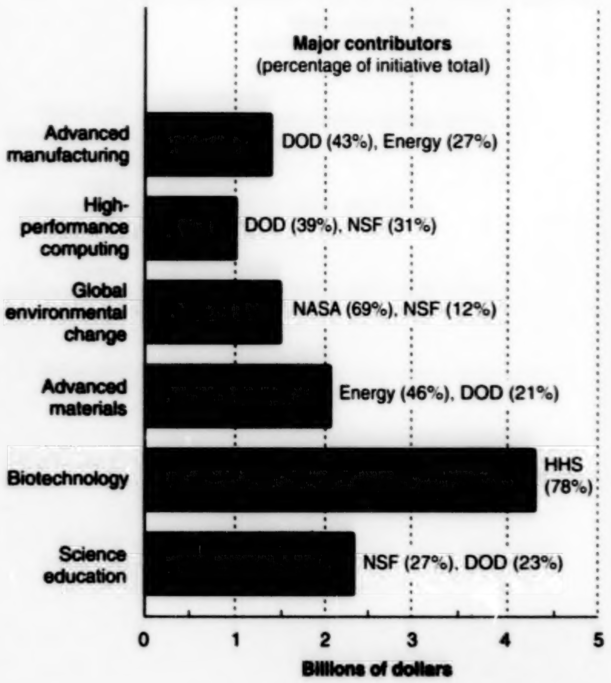
[44] There is a large dip in advanced technology development funding for years 1993 and 1994 (figure 4-18) because several major Star Wars projects moved from their technology development phase to their strategic development phase. Note also that in early 1993 the end of the Strategic Defense Initiative was formalized and the name of the administering office reverted to its former title, the Ballistic Missile Defense Organization.

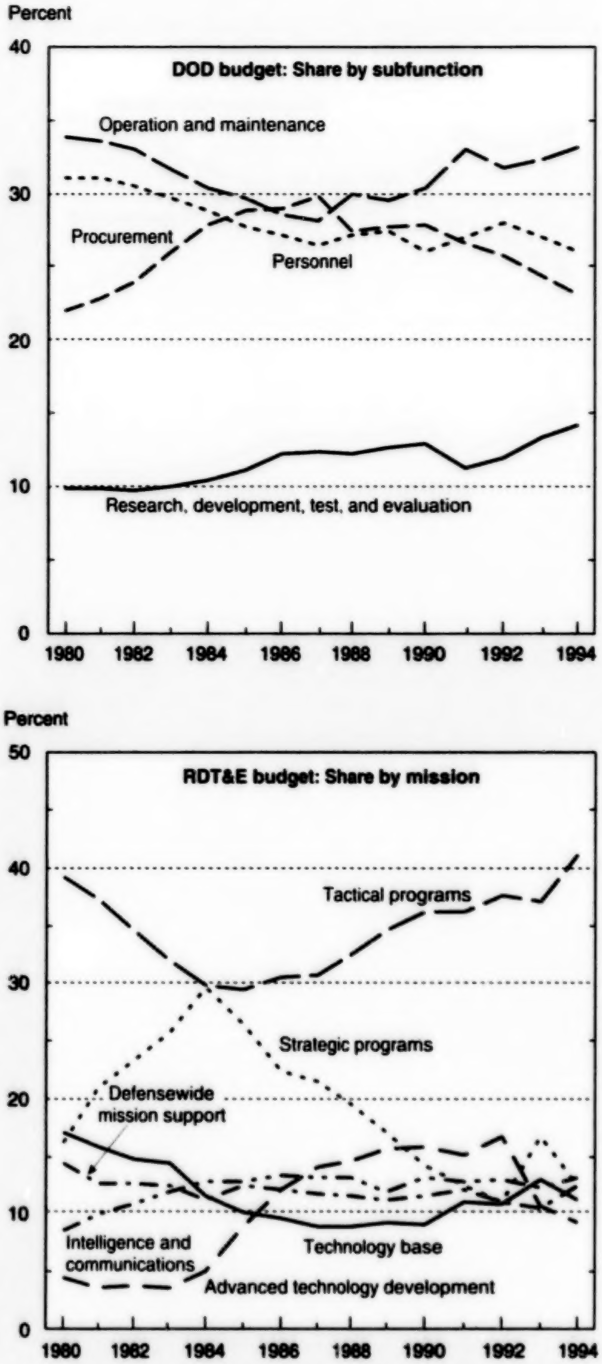
[45] The information presented here is based on DOD reports as of mid-1992. These reports (DOD 1992a and 1992b) outline the tenets of an S&T strategy that, despite being several years in the making, is still under considerable scrutiny and review. Additionally, recent decisions by the new administration may make certain aspects of the foregoing discussion inaccurate or obsolete.

Figure 4-17.
Federal funding for FCCSET initiatives: 1994



See appendix table 4-21. *Science & Engineering Indicators – 1993*

Figure 4-18.
Department of Defense budget for research, development, test, and evaluation



NOTE: RDT&E = research, development, test and evaluation.
See appendix tables 4-18 and 4-19.
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will invest almost $8 billion in fiscal year 1994 to support the Science and Technology Program, as follows:

- ◆ $1.3 billion in basic research support for 12 science and engineering disciplines DOD believes are not addressed adequately elsewhere—these are, in order of importance as indicated from estimated 1993 funding levels, electronics, ocean sciences, mechanics, materials, physics, chemistry, computer sciences, mathematics, biology and medicine, cognitive and neural sciences, atmosphere and space sciences, and terrestrial sciences;
- ◆ $3.1 billion in exploratory development (applied research) support[46] for 11 key technology areas deemed critical to future military needs—computers, software, sensors, communications networking, electronic devices, environmental effects, materials and processes, energy storage, propulsion and energy conversion, design automation, and human-system interfaces; and
- ◆ $3.6 billion in advanced technology development support for demonstration programs[47] in each of seven "S&T thrusts"—global surveillance and communication, precision strike, air superiority and defense, sea control and undersea superiority, advanced land combat, synthetic environments, and technology for affordability.

The facilitation of spin-off technologies from defense research to the civil and commercial sectors is specifically acknowledged as part of this S&T strategy.

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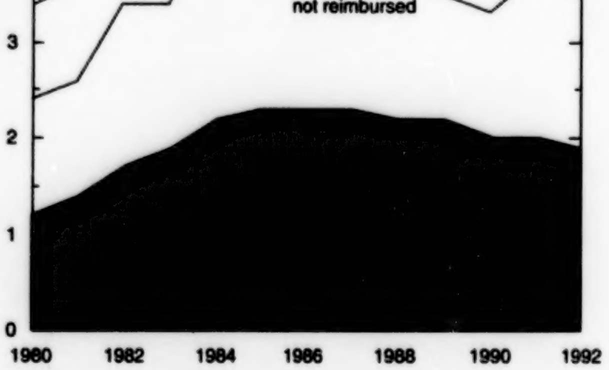
[46] Together with basic research, these funds comprise the DOD technology base budget category.

[47] One-third of these activities are funded through the Advanced Research Projects Agency.

Independent Research and Development. In addition to the federal R&D obligation support detailed above, DOD's Independent Research and Development (IR&D) Program enables industry to obtain federal funding for R&D conducted in anticipation of government defense and space needs. Because it is initiated by private contractors themselves, IR&D is distinct from R&D performed under contract to government agencies for specific purposes. IR&D allows contractors to recover a portion of their in-house R&D costs through overhead payments on federal contracts on the same basis as general and administrative expenses.[48]

Until very recently, all reimbursable IR&D projects were to have "potential military relevance." There has been some concern that the defense drawdown will serve to reduce the civilian R&D effort (Cohen and Noll 1992), not only in the form of commercial spillovers from weapons research but—more importantly—because of reductions in DOD procurement (see previous section), out of which IR&D is funded. Given the importance of IR&D to industry's investment in critical technologies identified by DOD, the issue has received congressional attention as well.[49] Thus, with these concerns in mind, the rules for reimbursement have been eased (see footnote 48) and the eligibility criteria broadened. Reimbursement is now permissible for a variety of IR&D projects of interest to DOD including those intended to enhance industrial competitiveness, develop or promote dual-use technologies, or provide technologies for addressing environmental concerns.[50]

Figure 4-19.
Independent research and development costs and reimbursements



NOTE: IR&D = independent research and development.

See appendix table 4-22. *Science & Engineering Indicators – 1993*

In 1992, industrial firms were estimated to have incurred $4.8 billion in IR&D costs, of which $4.2 billion were deemed eligible for reimbursement. The government reimbursed $2.3 billion, or 48 percent of the IR&D total.[51] This figure is up from the 37-percent share ($0.9 billion) reimbursed in 1980, at the start of the defense buildup. Notably, both the amounts incurred and the amounts reimbursed have held rather steady since 1984: After adjusting for inflation, however, these funds have declined considerably. (See figure 4-19.) As an equivalent proportion of combined DOD and NASA industrial R&D support, IR&D fell from 11 percent in 1984 to 8 percent in 1992. (See appendix table 4-22.) It remains unclear whether changes in the rules governing IR&D will have their intended effect of maintaining this industrial activity.

A snapshot of the Nation's total defense-related R&D expenditures is obtained by combining budgetary data from several programs. In addition to the federal defense funding component, a substantial amount of private funds supports activities with defense purposes. Federal defense funds comprise DOD spending from its RDT&E account and DOE R&D for its atomic energy defense activities. As previously mentioned, industry funds considerable IR&D that is only partially reimbursed by the government, but that nonetheless has potential military relevance. Adding together IR&D costs that are either reimbursed as overhead on defense contracts or not reimbursed increases total defense R&D by 10 percent for 1992. (See text table 4-5.) The

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[48] See NSB (1991) for a brief description—and Winston (1985) and Alexander, Hill, and Bodilly (1989) for more detailed accounts—of how reimbursement for IR&D was, at least until recently, determined. The exact process and criteria for determining reimbursement is, as of this writing, somewhat in flux. The National Defense Authorization Act for Fiscal Years 1992 and 1993 (P.L. 102-190) provides for the gradual removal of limitations on the amount DOD will reimburse contractors for IR&D expenditures and partially eliminates the need for advance agreements and technical review of IR&D programs.

[49] In fiscal year 1991, the military used $3.8 billion of its Science and Technology Program's $8.5 billion research total on support for DOD's 20 critical technologies. For 1990, industry contractors reported that $2.0 billion in IR&D and $0.8 billion in bid and proposal costs had been used to address the critical technology goals in DOD's plans. Bid and proposal costs are those incurred in preparing, submitting, and supporting bids and proposals on potential contracts, including technical background work (GAO 1992a).

[50] P.L. 101-510. These changes also apply to reimbursement eligibility for industry's bid and proposal overhead costs.

[51] NASA also reimburses some IR&D costs and closely follows DOD procedures. During the 1980s, the NASA reimbursements typically ran less than 5 percent of those by DOD. The data reported here are for only the 100 or so major defense contractors whose accounts are audited and reported by the Defense Contract Audit Agency, in accordance with P.L. 91-441. These companies account for an estimated 97 percent of all IR&D.

The fiscal year 1991 Defense Appropriations Act repealed the provisions that required collection of detailed IR&D statistics. Responding to congressional concerns that the information not be lost (GAO 1992c), the data series has—to date—been maintained, although sampling coverage has been reduced.

$44 billion estimated here for defense would be equivalent to 29 percent of the Nation's R&D total.

Defense Conversion: The Technology Reinvestment Project. National defense policies are being reassessed and redefined, especially as they relate to support of the Nation's joint military and commercial S&T interests. In particular, large amounts of money are being earmarked to help smooth the transition of defense-dependent resources to commercial and civilian activities. This "defense conversion assistance" reached approximately $1.7 billion in fiscal year 1993.[52] Issues related to the development and deployment of dual-use technologies—those with both defense and nondefense applications—have prominence in defense conversion proposals.

Certainly the largest and most notable of initial technology conversion efforts is the government-wide Technology Reinvestment Project (TRP). Funded in 1993 with almost $500 million taken out of the RDT&E budget of DOD's Advanced Research Projects Agency, TRP is an extremely complex mix of nine individual programs whose goal is to bolster the economic competitiveness of defense-dependent resources and increase the availability of dual-use technologies for national security purposes.[53]

Like FCCSET, TRP is a multi-agency cooperative effort, which is led by ARPA and involves NASA, DOE, NSF, NIST, and the Department of Transportation. ARPA has primary responsibility for promoting technology development activities, and NIST is responsible for deployment activities through its already existing Manufacturing Extension Services.

TRP's nine programs span the spectrum from creation of technologies to their commercialization and use; and from education and technology development, including spin-on and spin-off technologies,[54] to technology deployment, including regional outreach efforts. (See ARPA 1993 and figure 4-20.) Each program

- requires competitive awards;
- contains participation and organizational requirements for the involvement of firms, universities, nonprofit organizations, and state and local government agencies; and
- requires at least 50 percent cost sharing.

Text table 4-5.
National defense-related R&D support: 1992

	Billions — of dollars —
Defense-related R&D investments	44.2
Department of Defense RDT&E	37.4
Technology base	4.1
Research[1]	1.1
Exploratory development[1]	3.0
Advanced technology development	6.2
Strategic programs	4.5
Tactical programs	13.5
Intelligence and communications	4.6
Defensewide mission support	4.5
Department of Energy defense R&D	2.7
Basic research	0.0
Applied research	0.9
Development	1.8
IR&D with potential military relevance	4.2
Reimbursed ceiling	2.3
Unreimbursed ceiling	1.9

NOTES: Details may not sum to totals because of rounding.
IR&D = independent research and development; RDT&E = research, development, test, and evaluation.

[1] In Department of Defense budgetary documents, "Research" is often referred to as 6.1 money, and "Exploratory development" as 6.2 money.

SOURCES: Department of Defense, *RDT&E Programs (R-1): DOD Budget for Fiscal Year 1994* (Washington, DC: The Pentagon, 1993); DOD, unpublished tabulations; and Office of Management and Budget,unpublished tabulations.

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The three largest programs collectively account for more than one-half ($269 million) of total TRP funds. Rather than focus on developing new technologies, each of these programs is concerned partially (Regional Technology Alliances Assistance Program) or solely (Defense Dual-Use Assistance Extension Program and Manufacturing Extension Program) with deploying existing technology for near-term commercial and defense products and processes.

The initial indication is that TRP has garnered considerable industry interest. More than 2,800 proposals were submitted for 1993 funding. Proposed nonfederal matching funds totaled $8.4 billion in combined cash and in-kind contributions. This amount represented a 16-fold oversubscription to available government funds. About two-thirds of the proposals (75 percent of funds) dealt with develop-

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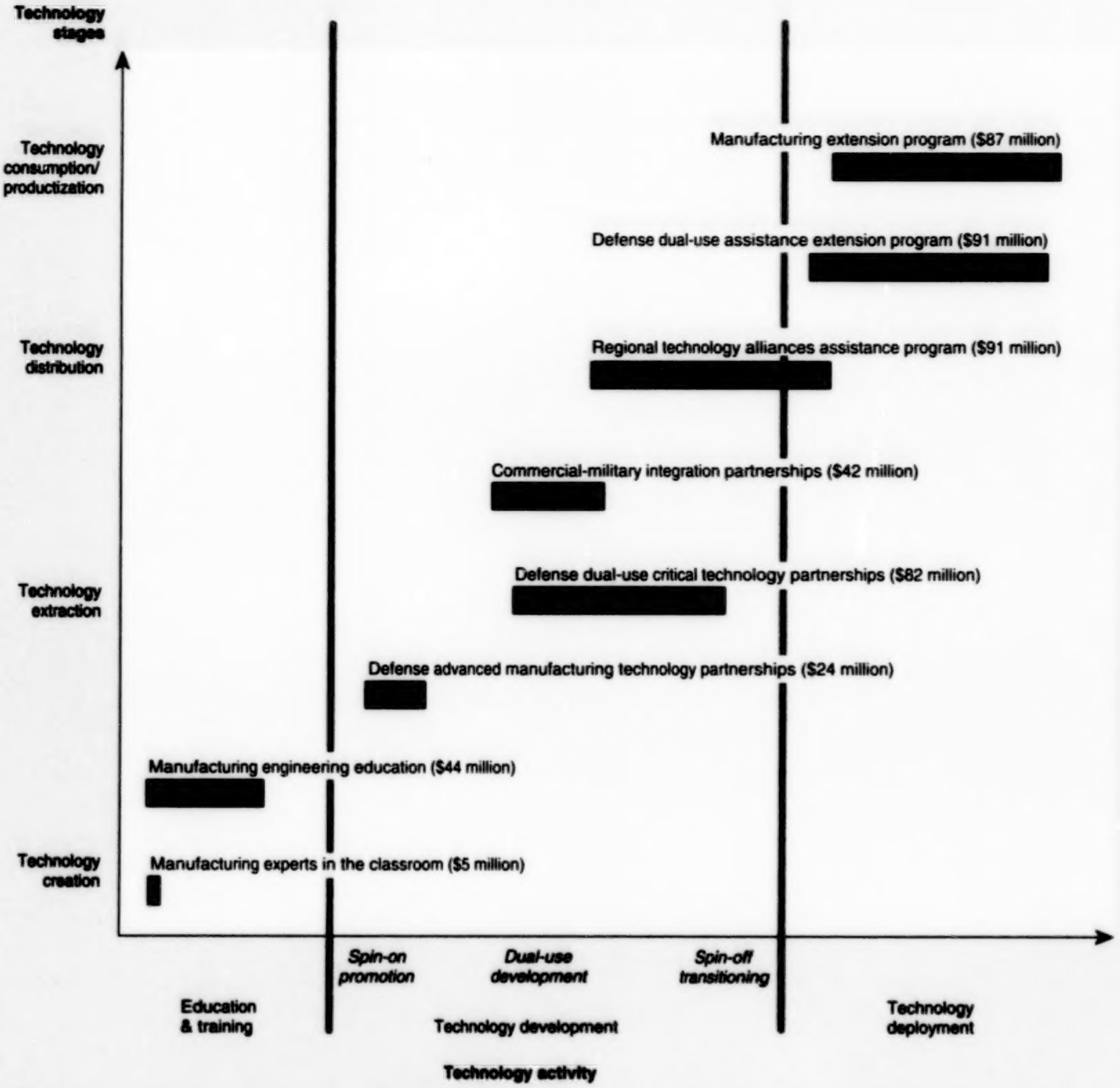
[52] Defense conversion is defined as the process by which the people, skills, technology, equipment, and facilities in defense are shifted into alternative economic applications. (See Defense Conversion Commission 1992.) Conversion funding goes to programs covering a wide variety of activities from technology development, to employee retraining, to economic relief for communities affected by defense plant closings.

[53] Authorizing legislation for TRP comes from title IV of the 1993 Defense Appropriations Act, which provides for eight specific programs plus a 1½-percent small business set-aside program. Funding is provided through ARPA's advanced technology development budget even though not all activities in TRP can rightly be considered R&D. Hence, not only are expenditures for defense versus nondefense R&D activities becoming increasingly indistinguishable in formal accounting documents, current funding trends may make even aggregate R&D estimates somewhat suspect.

[54] Technology development activities are intended to include applied development at the precompetitive level; basic research or final product development proposals are not funded here. Spin-on activities are those that demonstrate the defense utility of existing nondefense commercially viable technologies. Spin-off activities are those that demonstrate nondefense commercial viability of technologies already developed for defense purposes.

Figure 4-20.
R&D funding for defense conversion, by technology reinvestment program and activity emphasis: 1993



SOURCE: Technology Reinvestment Project, Advanced Research Projects Agency, *Program Information Package for Defense Technology Conversion, Reinvestment, and Transition Assistance* (Arlington, VA: ARPA, 1993).

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ing technologies, and one-fifth of the proposals (in terms of both number and dollar value) focused on deployment. The proposals included diverse multi-institution and multi-sector research teaming. On average, there were four or five participants per TRP proposal submitted.

Industry S&T Linkages

The industrial sector is both the largest R&D performer and the major R&D funder in the United States. Changes in industry's R&D activities therefore are not only important in their own right, but also as a barometer of activities likely to be observed in all sectors of the economy. Since the mid-eighties, there has been a slowing in the growth rate of public and private support for industrial R&D activities. Concurrent with the funding slowdown—indeed, partially in response to it—the number of cooperative research relationships among the various R&D-performing sectors of the economy has increased rapidly. Within the industrial sector, firms have forged a variety of domestic and international cooptors primarily as a cost-effective means of developing those generic technologies crucial to future sales growth. Companies also have established collaborative arrangements with laboratories outside of industry—including government and university labs—in an ongoing effort to develop external sources of R&D expertise, discover commercially viable technologies, and leverage scarce resources. In this section, indicators of U.S. industry's intra- and inter-sector R&D partnerships are discussed. The discussion closes by placing the U.S. industry R&D effort in a global context.

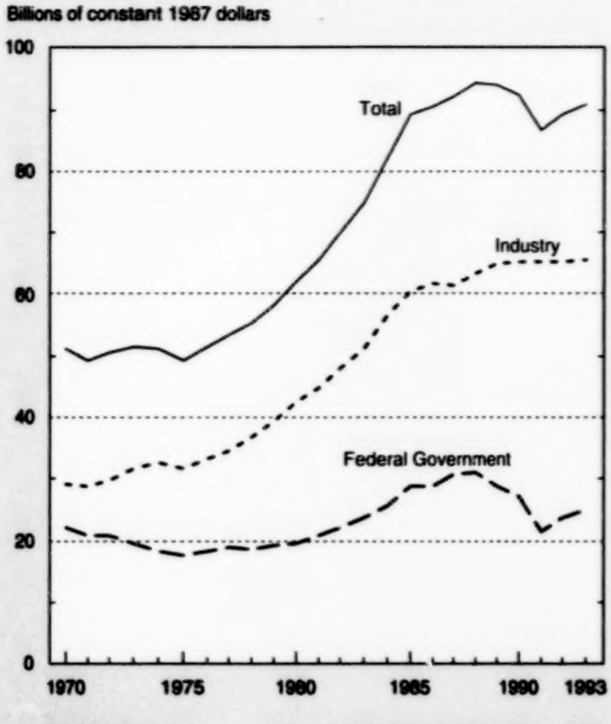
Industry-Government Interactions

Policies of the Federal Government influence industrial R&D activities in a variety of ways. Just as often, however, government policies are themselves a response to independent changes in the industrial technological enterprise. In this section, three components of industry-government S&T interplay are discussed: direct R&D support, tax policy, and institutional arrangements for the conduct and sharing of R&D. The focus here is on indicators of collaboration between firms and federal laboratories. The following sections contain indicators of other industry R&D partnerships that government policy helps foster.

Direct R&D Support, by Industry. From the early seventies through the early eighties, the share of industrial R&D activity financed by the Federal Government declined rather steadily from about 40 percent of the performance total to about a 30-percent share in each year from 1980 to 1984.[55] (See figure 4-21.) This trend was reversed with the defense buildup of the 1980s, which brought increased funding for the development and upgrading of military technologies. This buildup caused the percentage gains in the federal R&D contribution to first keep pace with, and later slightly surpass, the private contribution. Since 1987, federal support to industry has fallen considerably—after adjusting for inflation—and industry's R&D self-funding has been basically flat. (See "R&D Funders.") By 1993, the Federal Government provided just one-fourth of the money used to fund industrial R&D performance; private financing accounted for the remaining three-quarters of industry's total R&D expenditures.

Two industries received 76 percent ($19 billion) of total federal R&D support to the industrial sector ($25 billion) in 1991, the most recent year for which industry-specific detail is available. *Aircraft and missile companies* received a combined $15 billion; firms in the *communication equipment* industry were federally funded at $4 billion.[56] The high concentration of the federal R&D budget in these two industries stems from the funding primacy of DOD (see text table 4-3), coupled with the development emphasis in defense R&D (see figure 4-14): Such large-scale projects are not easily spread among multiple firms or multiple industries. For example, only 4 percent ($0.9 billion) of federal 1991 R&D funding to industry went to firms with 500 or fewer employers; 84 percent of such funds went to firms with more than 25,000 employees. (Industry-specific trend data are displayed in appendix tables 4-31 through 4-33. Industry-specific international comparisons are analyzed in chapter 6, and federal small business R&D support is summarized in "SBIR Program Continues to Fuel Small Business R&D.")

Figure 4-21.
U.S. industrial R&D expenditures, by source of funds



See appendix table 4-3. *Science & Engineering Indicators – 1993*

Industries vary considerably in their dependence on federal R&D funding. Not surprisingly, ***aircraft and missile*** companies received especially large portions of their R&D support from federal sources—fully 70 percent. (See figure 4-23.) Forty percent of R&D performance in the ***communication*** equipment industry was federally funded, as was 28 percent of the entire

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[55] These figures exclude R&D performance within the various industry-administered FFRDCs. Including the R&D performed in those labs—which by definition is 100-percent federally funded—the federal share of total industry R&D performance is 1 to 3 percentage points higher each year.

[56] This support is provided largely under the aegis of R&D federal defense contracts. Such contracted R&D expenditures are in addition to IR&D overhead allowances to industry on military procurements by the government. See "Independent Research and Development."

SBIR Program Continues to Fuel Small Business R&D

Small business is a significant source of innovation and a successful mover of R&D results into new products. The Small Business Innovation Research (SBIR) Program was created in 1982 with the intent of strengthening the role of small firms in federally supported R&D. Since that time, more than $3 billion in R&D support has been competitively awarded to qualified small businesses (SBA 1992b). Under this program, which is coordinated by the Small Business Administration (SBA), when an agency's external R&D obligations (that is, those exclusive of in-house R&D performance) exceed $100 million, the agency must set aside a fixed percentage of such obligations for SBIR projects. This percentage was originally 1.25 percent, but under the Small Business Research and Development Enhancement Act of 1992, it will rise incrementally to 2.5 percent by 1997.

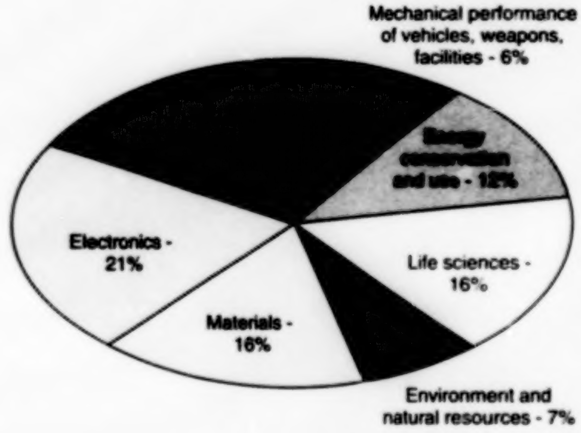
To obtain funding, a company applies for a phase I SBIR grant: The proposed project must meet an agency's research needs and have commercial potential. If approved, grants of up to $50,000 are made so that the scientific and technical merit and feasibility of an idea may be evaluated. If the concept shows potential, the company can receive a phase II grant of up to $500,000 to develop the idea further. In phase III, the innovation must be brought to market with private sector investment and support. No SBIR funds may be used for phase III activities.

Eleven federal agencies participated in the SBIR Program in 1991, making awards totaling $483 million, an amount equivalent to 0.8 percent of all government R&D obligations. Although three-fourths of the grants awarded were phase I grants, roughly 75 percent of total SBIR funds were disbursed through phase II grants. Approximately half of all SBIR obligations were provided by DOD, mirroring this agency's share of the federal R&D funding total. (See appendix table 4-23.)

By most accounts, the SBIR Program has been a success. To SBA's favorable self-assessment of the program's commercialization accomplishments (SBA 1992a) is added generally positive critiques from nonagency reviewers. For example, the General Accounting Office (1992b) estimates that, through mid-1991, the SBIR program had generated $1.1 billion in sales and additional developmental funding, with $2 billion more expected by 1993 year end. (The program also receives positive reviews when assessed from a state economic development perspective; see Anuskiewcz 1992.)

SBA classifies SBIR awards into various technology areas. (See appendix table 4-24.) In 1991, the technology areas receiving the largest (value) share of phase I awards were information processing and optical lasers; information processing and biotechnology were the leading technology areas for phase II awards. In terms of all SBIR awards made during the 1983-91 period, roughly one-fifth were computer-related and one-fifth involved electronics. Both of these technology areas received more than one-half of their support from DOD and NASA. One-sixth of all SBIR awards combined went to life science research, the bulk of such funding being provided by HHS. Materials-related research, which is funded largely by DOE and NSF, accounted for another sixth of total SBIR awards. (See figure 4-22.)

Figure 4-22.
Small Business Innovation Research awards, by technology area: 1983–91



See appendix table 4-24. *Science & Engineering Indicators – 1993*

was federally funded, as was 28 percent of the entire *electrical equipment* industry. The Federal Government also provided a large share of R&D funding to certain nonmanufacturing industries. In 1991, it supplied nearly one-third of the R&D funds used by firms whose primary activity involves R&D and testing services and more than one-fourth of the R&D funds used by computer-related and engineering services firms. (See appendix table 4-34.)

R&D Tax Credits. In addition to direct financial R&D support, the government has tried to stimulate corporate spending indirectly by offering tax credits on incremental research and experimentation (R&E) expenditures.[57] The credit was first put in place in 1981 and has since been renewed six times—most recently, through the

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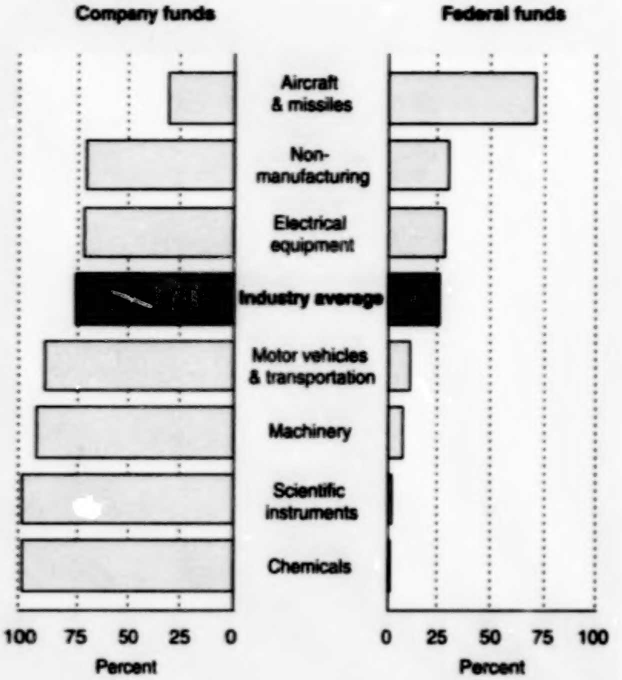
[57] Not all R&D is eligible for such credit, which is limited to expenditures on laboratory or experimental R&D.

Figure 4-23.
Share of industrial R&D funding, by source and industry: 1991



See appendix tables 4-31, 4-32, and 4-33.
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end of June 1995.[58] Although the computations are complicated, the tax code provides for a 20-percent credit for the amount by which a company's qualified R&D exceeds a certain threshold.[59] The Tax Reform Act of 1986 allowed companies to claim a similar credit for basic research grants, contributions, and contracts to universities and other qualifying nonprofit institutions; this credit also is in effect through mid-1995.

As part of the federal budget process, the Treasury Department annually calculates estimates of foregone tax revenue ("tax expenditures") due to preferential tax provisions, including the R&E tax credit. As one measure of budgetary effect, the Treasury provides outlay-equivalent figures: These allow a comparison of the cost of this tax expenditure with that of a direct federal R&D outlay. (See "Definitions.") Between 1981 and 1992, more than $20 billion was provided to industry through this indirect means of federal R&D support—an amount equivalent to about 3 percent of direct federal R&D support. (See appendix table 4-25.) In general, based on data available through the mid-eighties, the companies that took the most advantage of the credit were large firms that produce scientific instruments, office and computing machinery, chemicals, and electrical equipment (GAO 1989).[60]

Technology Transfer and Commercialization. Industry representatives (Burton 1992) have sounded the call to open federal labs up to private enterprise for the benefit of the entire Nation. At the heart of this debate is the belief that the $20-plus billion in research activities undertaken by government have—if properly focused and directed—commercial applicability. (See "Patterns in Federal Lab R&D Performance.") Federal concern over U.S. industrial strength and world competitiveness has thereby catalyzed efforts to transfer technologies developed in federal laboratories to the private sector. Four measures of the extent of federal technology commercialization efforts and federal-industry collaboration are presented in this section—invention disclosures, patent applications, cooperative research and development agreements (CRADAs), and licenses granted.

The term "technology transfer" can cover a wide spectrum of activities, running the gamut from the informal exchange of ideas between visiting researchers to contractually structured research collaborations involving the joint use of facilities and equipment. Only recently, however, have technology transfer activities become an important mission component of federal labs—although some agencies have long shared their research with the private sector (e.g., USDA's Agricultural Research Experiment Stations and NASA's civilian aeronautics programs), and several laws passed in the early 1980s encouraged such sharing (notably, the 1980 Stevenson-Wydler Technology Innovation Act).

One reason for this new emphasis on technology transfer stems from practical considerations: Industry is interested,[61] federal money is available, and government defense labs are amenable to and available for such activities as an alternative to their declining defense work (OTA 1993). Another reason is recent legislative changes. Whereas the Federal Technology Transfer Act (FTTA) of 1986 authorized government-owned and -operated laboratories to enter into CRADAs with private industry, it was not until the 1989 passage of the National Competitiveness Technology Transfer Act (NCTTA), that contractor-operated labs (including DOE's FFRDCs) could also enter into CRADAs.

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[58] Reflecting the tentative political support afforded the credit since its inception, it was allowed to expire on June 30, 1992. After more than a year in limbo, the credit was extended by the Omnibus Budget Reconciliation Act of 1993 for 3 years retroactive to July 1992.

[59] The complex base structure for calculating qualified R&D spending was put in place by the Omnibus Budget Reconciliation Act of 1989. With various exceptions, a company's qualifying threshold is the product of a fixed-base percentage multiplied by the average amount of the company's gross receipts for the 4 preceding years. The fixed-base percentage is the ratio of R&E expenses to gross receipts for the 1984-88 period. Special provisions cover start-up firms.

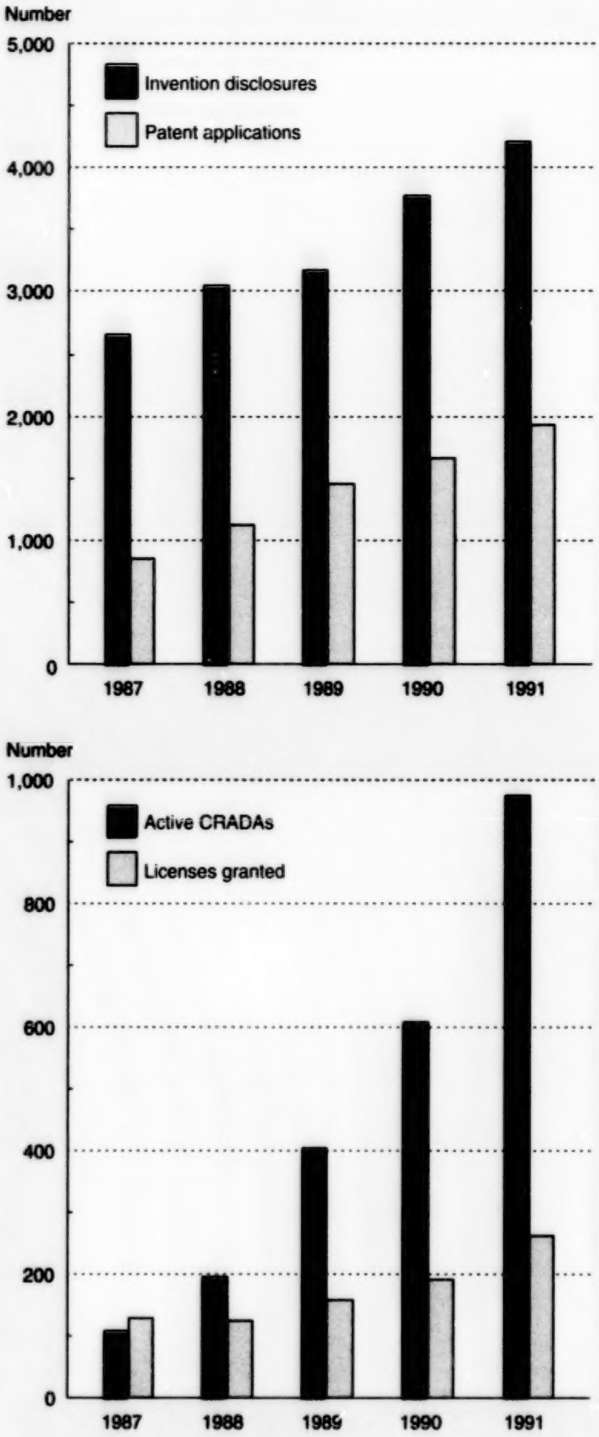
[60] In an early assessment of the tax's effect on R&D spending, Cordes (1989) found conflicting evidence: Studies based on corporate tax returns and on *aggregate* time-series modeling indicated significant stimulatory effects; considerably more moderate results were indicated from studies based on *company-specific* time-series analyses, industry questionnaire responses, and evidence from other countries. In contrast, Hall (1992)—using more recent and extensive publicly available company-specific data on R&D spending—concludes that the tax credit has had its intended effect, although it took several years for firms to fully adjust R&D spending patterns to take advantage of opportunities provided by the credit. She estimates that the amount of additional R&D spending induced by the credit was twice the cost in foregone tax revenue.

Whatever its ultimate impact on R&D spending, the tax credit has certainly influenced spending less than had it been less subject to erratic legislative treatment. The tax credit has had to be repeatedly (almost annually) renewed, its calculation provisions have changed considerably over the years, and it was even allowed to lapse for more than a year—all of which circumstances created considerable uncertainty for businesses that would otherwise have planned to take the tax credit.

According to most available indicators, federal efforts to facilitate private sector commercialization of federal technology have made considerable progress since 1987. (See figure 4-24.)

- ◆ The number of active CRADAs between federal labs and private industry increased ninefold, rising from 108 in 1987 to almost 975 in 1991.[62] NASA (at 25 percent of the total) and USDA (with 18 percent of the total) accounted for the largest number of CRADAs in 1991; DOE's CRADA total rose from 1 in 1990 to 43 the next year.
- ◆ Federal labs increased their number of invention disclosures[63] by 60 percent, and more than doubled their number of patent applications between 1987 and 1991. DOD led all other agencies in these efforts.
- ◆ The number of exclusive and nonexclusive licensing agreements between firms and federal laboratories increased by 100 percent. DOE granted the largest number of licenses (351) to industry in the 1987-91 period.

Figure 4-24.
Federal technology transfer indicators



NOTES: CRADA = cooperative research and development agreement. Includes agreements entered into by NASA

See appendix table 4-29. *Science & Engineering Indicators – 1993*

Industry-University Partnerships

Since the late seventies, there has been a considerable increase in industry's interactions with university researchers. By supporting academia, industry gains access to both cutting-edge research and a downstream employment pool. For entrepreneurial university researchers, industry collaboration offers an additional source of funding and intellectual stimulation, access to state-of-the art facilities, and special educational opportunities for their students. Industry-university interactions have, during the past decade or so, benefited from a variety of federal and state programs set in place explicitly to encourage such collaboration.[64]

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[61] Industry's recent interest in federal lab technologies and expertise is documented by Roessner and Bean (1993). Between 1988 and 1992, there was a significant increase in both formal (cooperative, contract and sponsored research, technology licensing, and employee exchange) and informal (information dissemination, company visits to federal labs, seminars, and technical consultation) interactions between federal labs and industrial firms. And although the frequency of informal interaction was more extensive, cooperative research with federal labs apparently holds much promise among company research directors. More than 70 percent of them agreed with this view in 1992; only 35 percent of these directors had held this opinion in 1988. Significantly, about 40 percent of the 1992 industry respondents said that their labs had interacted "rarely" or not at all with federal labs during the past 2 years. In 1988, that proportion was virtually identical. The authors note that companies with relatively extensive experience in working with federal labs have increased the frequency of their interaction—familiarity has bred collegiality. The greatest increases in such interactions have been in licensing and cooperative research.

[62] Office of Technology Commercialization (1993b). These figures include NASA's cooperative R&D agreements which are authorized by the National Aeronautics and Space Act of 1958. Excluding the NASA totals, there were 731 active CRADAs in 1991. As of mid-1993, those 10 agencies, excluding NASA, that have elected to use CRADAs had 1,500 active or completed CRADAs (Grant Stockdale, monthly).

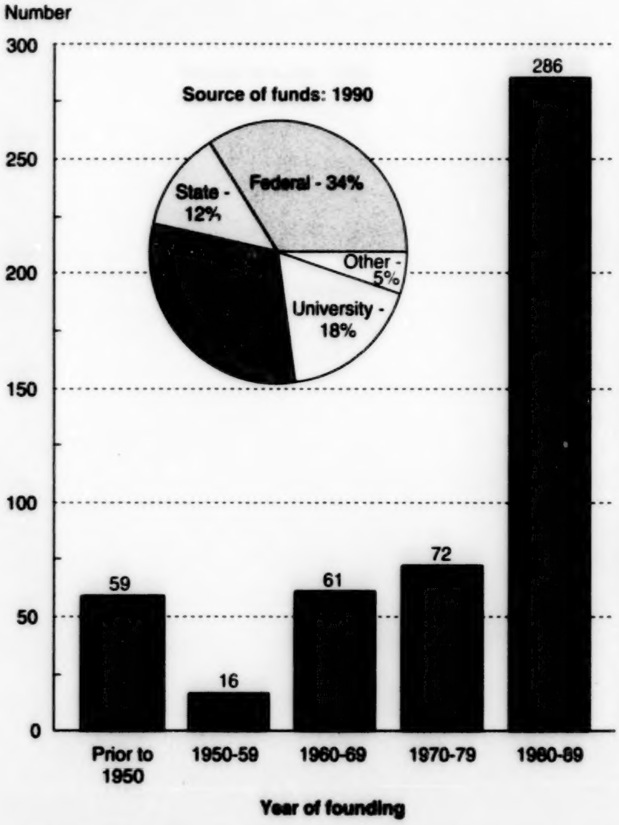
[63] Under its Disclosure Document Program, the Patent and Trademark Office accepts and preserves for a 2-year period papers disclosing an invention, pending the filing of an application for a patent (Patent and Trademark Office 1989). This disclosure is accepted as evidence of when the invention was conceived; it does not, however, provide any patent protection.

Two indicators of the expanding industry-university network are (1) industry's academic R&D funding support in general and (2) the growth of university-industry research centers (UIRCs) in particular.

Nationwide, industrial sources of support for academic R&D have grown faster than all other sources of support, increasing more than 300 percent in constant dollars from 1978 to 1993. In contrast, support from other sources has doubled during this 15-year period. (See appendix table 4-3.) There has, however, been some recent slowing in the *rate* of industrial funding growth, from annual average gains of 12.3 percent between 1978 and 1986, to an estimated 7.8-percent increase per year since then. This deceleration in industry's academic research support parallels broader trends in industrial R&D funding documented elsewhere ("R&D Funders") As a proportion of the Nation's total academic R&D effort, industry sources of support increased from 3 percent in 1978 to an estimated 7 percent (or $1.5 billion) in 1993.

Although research funds are distributed to academic investigators through various means, it would appear that the most used mechanism by far is via industry funding of university-affiliated research or technology centers. From a comprehensive national survey, Cohen, Florida, and Goe (1993) estimate that the 1,000-plus UIRCs existing in 1990 expended $2.7 billion on R&D activities. This research was funded out of an estimated total UIRC budget of $4.3 billion; most of the remaining budget was spent on UIRC education and training activities. Industry funded 31 percent of UIRCs' total budget (see figure 4-25) which is a share that far exceeds industry's overall 7-percent academic R&D funding share. Furthermore, the sheer number of UIRCs established in the 1980s—four times more than the number founded in the 1970s—attests to the growing importance of these industry-university partnerships. Other findings of the centers study follow.

Figure 4-25.
Growth in university-industry research centers, and source of funds



NOTES: Data are for centers existing in 1990. Of an estimated 1,058 centers, 458 provided funding data and 494 provided founding data.

SOURCE: W. Cohen, R. Florida, and W.R. Goe, "University Industry Research Centers in the United States: Final Report to the Ford Foundation (Pittsburgh: Carnegie Mellon University, 1993).

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♦ Company involvement in UIRCs is widespread: The average number of businesses participating per center in 1990 was 17.3, and the median was 6.

♦ The UIRC R&D effort is divided roughly into 43 percent basic research, 41 percent applied research, and 16 percent development.

♦ Centers are involved in a broad range of activities, not all of which would be considered high-technology areas. Of the 502 UIRCs reporting this information, 42 percent undertook R&D related to the chemicals and pharmaceuticals industry, 35 percent reported doing R&D related to computers, 29 percent to electronic equipment, 29 percent to petroleum and coal products, and 26 percent to software.

♦ A main reason industry support was sought by universities was to offset what is perceived to be inadequate research funding from government. Yet 72 percent of the UIRCs were established either wholly or partially based on funding provided by the federal or state government; of those, 83 percent indicated that they would not have been established in the absence of government funding.

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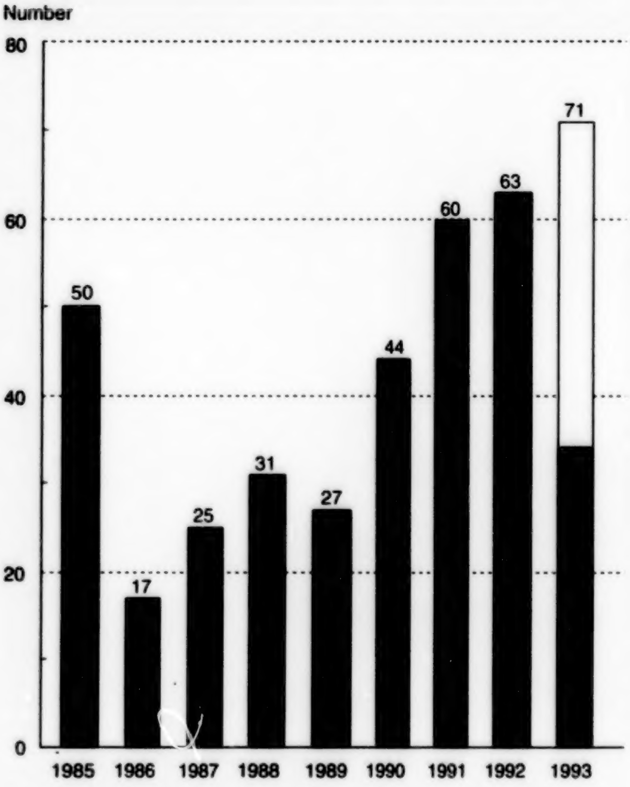
[64] See NSB (1991), chapter 4, for a brief review of the extent of state-initiated activities. An important component of most state technology development strategies is to provide funding and/or organizational support for linking, and thereby building on, existing in-state academic research and industrial technological strengths. Furthermore, over the past two decades, NSF initiated several programs in engineering and other disciplines to build research centers at universities partly to encourage interdisciplinary research and partly to stimulate interaction between academia and industry. For further information on the impact of government's technology policies on industry-university research relationships, see Government-University-Industry Research Roundtable (1991).

- Among the most effective mechanisms for technology transfer are collaborative R&D projects and informal meetings between university and industry researchers.

Industry-Industry Partnerships

Although longitudinal data on multi-firm collaborative R&D activities are wanting, there is significant anecdotal evidence to indicate considerable increase in such partnerships. There is also a growing body of literature that assesses the reasons for the increase in these partnerships, their organizational structure, and their economic and political implications.[65] Most intra-industry collaborations seem to be a response to the same competitive factors affecting all industries: rising R&D costs and risks in product development, shortened product life cycles, increasing multidisciplinary complexity of technologies, and intense foreign competition in domestic and global markets.[66] It also would appear that most cooperative research is not meant to substitute for, but rather to complement, firms' in-house research activities. In this section, several indicators on national and international intra-industry cooperative R&D are discussed.

Figure 4-26.
Growth in R&D consortia registered under the National Cooperative Research Act



NOTE: Unshaded part of 1993 total estimated from filings as of June 1993 (shaded part of bar).

SOURCE: Office of Technology Commercialization, Department of Commerce, *Research and Development Consortia Registered Under the National Cooperative Research Act of 1984* (Washington, DC: DOC, 1993).

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Domestic R&D Consortia. U.S. industry has benefited from certain federal provisions enacted to create a more favorable environment for multi-firm cooperative relationships, the most notable being the National Cooperative Research Act (NCRA)of 1984. NCRA encourages research collaboration among industry competitors by better defining joint R&D ventures (JRVs) and protecting them from antitrust suits.[67] Through June 1993, more than 350 filings of U.S. cooperative research ventures had been registered under the act (Office of Technology Commercialization 1993a). After an initial rush to register in 1985, the number of filings fell off significantly in the next few years. However, since 1989, the number of registered JRVs has grown annually, and had surpassed its 1985 level by 1991. (See figure 4-26.)

Up to half the filings are for project-specific—often two-member—ventures, not all of which are currently ongoing. Many of the other JRV formal filings have been made by firms—or their research organizations—in three regulated utility industries—telecommunications, electric power, and gas/oil. Nonetheless, NCRA does seem to have encouraged growth in the number of multi-firm R&D consortia whose focus is generic, precompetitive research projects; and joint research ventures have been registered in industries with activities as diverse as software, pharmaceuticals, semiconductors, sensors, and forest products.[68] An indeterminate number of the registered consortia have gained federal support, including some of the more well-known endeavors such as DOD's funding for Sematech and DOE's participation in the Advanced Battery Consortium.[69]

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[65] See, for example, Link and Bauer (1989) and Vonortas (1991).

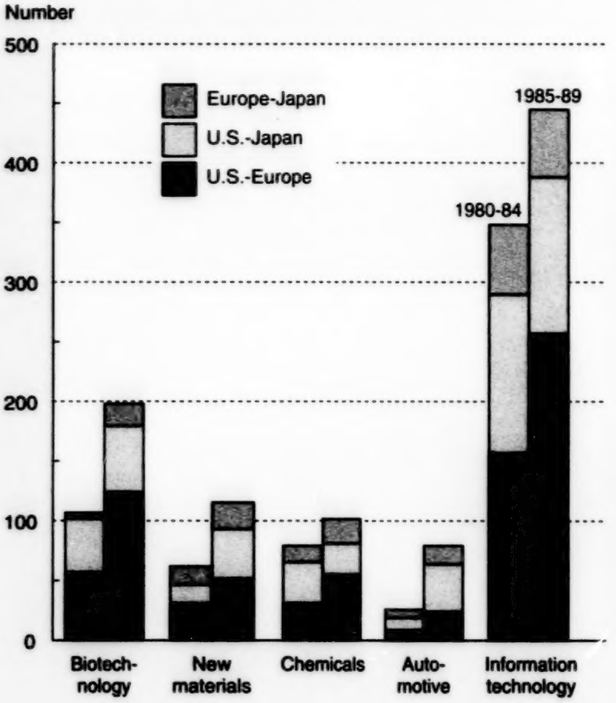
[66] See Douglas (1990) for a concise summary of the benefits of R&D collaboration, and Mowery (1989) on research collaboration between U.S. and foreign firms.

[67] NCRA states that JRVs will not automatically be considered illegal as anti-competitive, but that such consortia will be judged after weighing potential benefits and costs. Further, NCRA limits potential liability for JRV behavior that ultimately is ruled anti-competitive to actual costs rather than treble damages as is otherwise the norm. See Link and Tassey (1989).

[68] The full extent of domestic multi-firm research collaboration is unknown. In fact, one somewhat outdated estimate holds that up to 90 percent of all U.S. industry cooperative research arrangements in 1984 were informal partnerships (Link and Bauer 1989).

[69] Unfortunately, there does not seem to be a comprehensive list on federal participation in, and support to, the various industry R&D consortia.

Figure 4-27.
New transnational corporate technology alliances, by industry and region



See appendix table 4-42. *Science & Engineering Indicators – 1993*

International Strategic Technology Alliances.[70] Alongside growth in domestic collaborative R&D activities during the 1980s and into the early 1990s, there is evidence of a sharp increase in transnational joint research funding throughout the industrialized world. The number of international multi-firm R&D alliances grew from 86 in 1973-76, to 177 in 1977-80, to 509 in 1981-84, to 988 in 1985-88 (Hagedoorn 1990).

As the numbers have increased, the forms of cooperative activity has changed somewhat. The most prevalent modes of global industrial R&D cooperation in the 1970s were through joint ventures and research corporations. In these arrangements, at least two companies share equity investments to form a separate and distinct company; profits and losses are shared according to the equity investment.[71] In the second half of the 1980s, joint nonequity R&D agreements became the most important form of partnership. Under such agreements, two or more companies organize joint R&D activities to reduce costs and minimize risk, while pursuing similar innovations. The participants share technologies but have no joint equity linkages.

Formation of these so-called strategic technology alliances (both equity and nonequity arrangements) are particularly extensive among high-tech firms. Splitting the past decade into two quinquennia (1980-84 and 1985-89) reveals growth in international research collaboration by firms in a variety of industries, with especially steep rises in biotechnology and information technology areas. (See figure 4-27.) The largest regional growth in R&D cooperation was between U.S. and European firms. However, there also was considerable partnership activity between U.S and Japanese firms. There were somewhat fewer—but still a substantial number of—European-Japanese strategic technology alliances.

U.S. Industry's Overseas R&D.[72] Stiff international competition in research-intensive and high-technology products has compelled U.S. industry to expand its overseas research activities.[73] Much of the R&D undertaken abroad is not meant to *displace* domestic R&D, but rather to *support* overseas business growth—for example, to help in tailoring products for the specific needs of foreign customers.

From 1980 to 1991, U.S. firms generally increased their funding of R&D performed outside of the country. (See appendix table 4-40.). During the first half of this period, however, the overseas funding growth did *not* keep pace with the rise in company-financed R&D performed within the United States. Instead, company-financed R&D performed abroad was equivalent to 10 percent of the domestically performed total in 1980 and declined steadi-

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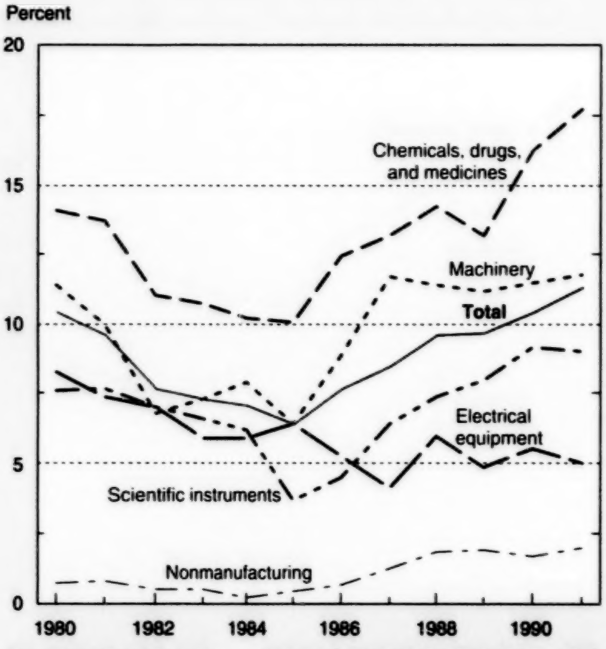
[70] Information in this section is drawn from an extensive database compiled in the Netherlands (Maastricht Economic Research Institute on Innovation and Technology's Co-Operative Agreements and Technology Indicators database—MERIT-CATI) on nearly 10,000 interfirm cooperative agreements involving 3,500 different parent companies. In the CATI database, only inter-firm agreements that contain some arrangements for transferring technology or joint research are collected. The data summarized here (from Hagedoorn and Schakenraad 1993) are restricted to *strategic technology partnerships* such as joint ventures for which R&D or technology sharing is a major objective, research corporations, joint R&D pacts, and minority holdings coupled with research contracts. CATI is a literature-based database; its key sources are newspapers, journal articles, books, and specialized journals that report on business events. CATI's main drawbacks and limitations are that (1) data are limited to activities publicized by the firm, (2) agreements involving small firms are likely to be underrepresented, (3) reports in the popular press are likely to be incomplete, and (4) it probably reflects a bias because it draws primarily from English-language materials. CATI information should therefore be viewed as indicative and not comprehensive.

[71] Joint ventures are companies that have shared R&D as a specific company objective, in addition to production, marketing, sales, etc. Research corporations are joint R&D ventures with distinctive research programs.

[72] The indicators discussed here reveal the growth in industrial global R&D activities. Public sector international S&T linkages are also on the rise. See, for example Carnegie Commission (1992b) for a review of recent trends in U.S. foreign S&T policy, including a summary of several indicators (for example, changes in State Department S&T staffing and the number of international S&T agreements). See also the short OECD treatise (1993b) and PCAST (1992) on big science funding. The high costs of scientific megaprojects increasingly necessitates international collaboration.

[73] Companies consider several factors before undertaking R&D overseas: Market access and accommodation of local requirements are but two of these factors. Tax and regulatory policies, as well as the availability of trained researchers and access to new scientific and technological developments in other countries, also influence R&D location decisions.

Figure 4-28.
U.S. overseas R&D as a share of company-financed domestic R&D, by industry



See appendix table 4-40. *Science & Engineering Indicators – 1993*

ly to a low of 6 percent by 1985. Since then, however, U.S. firms' overseas R&D component has increased nine times faster than that performed domestically (11.4 versus 1.3 percent average annual constant dollar growth between 1985 and 1991). Overseas R&D is now equivalent to more than 11 percent of industry's on-shore R&D expenditures. (See figure 4-28.)

U.S. companies and their foreign subsidiaries in the chemicals (including drugs and medicines), transportation, and machinery (including computers) industries account for the largest shares and growth of this foreign-based R&D activity. Indeed, drug companies accounted for 19 percent of total 1991 overseas R&D ($8.7 billion), which was equivalent to 27 percent of the industry's domestically financed R&D. Nonmanufacturing industries had the lowest share of privately financed R&D conducted overseas, despite a fivefold increase in this share since 1985—rising from 0.4 to 2.0 percent in 1991.

Most of the U.S. overseas R&D is undertaken in Europe. As indicated by data from the Bureau of Economic Analysis (BEA) on majority-owned foreign affiliates of nonbank U.S. multinational companies, 76 percent of the 1991 R&D total was performed in Europe—primarily Germany (27 percent), the United Kingdom (17 percent), France (9 percent), and Ireland (6 percent). By affiliate industry classification, more than one-half of the German-based R&D was performed by transportation equipment companies; in the United Kingdom and France, the chemicals industry accounted for more than one-third of the totals; in Ireland, computer-related research dominates. R&D in Canada accounts for 11 percent of U.S companies' 1991 R&D performed abroad, and that in Japan for 6 percent.[74] (See text table 4-6 and appendix table 4-41.)

According to BEA (Mataloni 1992), the majority-owned foreign affiliate share of U.S. multinational companies' worldwide R&D expenditures increased from 9 percent in 1982 to 13 percent in 1990. This increase reflects both the faster growth in foreign operations than in U.S. operations and the introduction of U.S. computer manufacturers to foreign research consortia as they sought to share the cost of developing new technologies.

Foreign R&D in the United States.[75] Since 1981, the percentage of industry R&D expenditures financed from foreign sources has risen considerably in each of the seven largest R&D-performing countries except Japan. Foreign R&D accounts for more than 10 percent of industry's 1990 total in the United States, Canada, the United Kingdom, and France; and for more than 3 percent of industry funds in Italy and Germany. Indeed, according to OECD data (1993a) on the 12 nations that comprise the European Community,[76] the combined share of their industries' R&D performance that is foreign controlled has risen from less than 5 percent in 1981 to 8 percent in 1990. The foreign component of Japan's domestic industrial R&D performance has held steady during the 1981-91 period at about 0.1 percent. (See figure 4-29 and "R&D Funding by Source and Performer.")

Like U.S. firms' overseas R&D funding trends, R&D activity by foreign-owned companies in the United States has increased significantly since the early eighties. From 1980 to 1990, inflation-adjusted R&D growth from foreign firms (U.S. affiliates in which the foreign parent owns 10 percent or more of the voting equity) averaged 14 percent per year, or more than three times the rate of

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[74] These overseas R&D *country* shares are from the BEA survey on U.S. Direct Investment Abroad (BEA annual series), not the NSF data series from which *industry-specific* shares are taken. The definition used by BEA for R&D expenditures is from the Financial Accounting Standards Board Statement No. 2; these expenditures include all charges for R&D performed for the benefit of the affiliate by the affiliate itself and by others on contract. BEA detail are available for 1982, and annually since 1989. NSF reports a 1991 overseas R&D total of $8.7 billion; BEA estimates overseas R&D expenditures by U.S. companies and their foreign affiliates at $9.4 billion.

[75] For countries other than the United States, the data in this section are taken from OECD (1993a). The foreign-sourced R&D data for the United States come from an annual survey of Foreign Direct Investment in the United States conducted by BEA. BEA reports that the foreign R&D totals are comparable to the U.S. R&D business data published by NSF. Industry-specific comparisons, however, are limited due to differences in the industry classifications used by the two surveys. (See Quijano 1990.)

[76] These countries are Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom. See also OECD (1992) for a discussion of international R&D investment trends.

Text table 4–6.
R&D performed for majority-owned foreign affiliates of U.S. parent companies, by selected country and industry of affiliate: 1991

Country	All industry	Manufacturing						Services
		Total manufacturing	Chemicals	Machinery	Electrical equipment	Transportation equipment		
	Millions of dollars							
Total	9,358	8,057	2,354	1,443	737	2,220		502
Europe	7,109	6,208	1,836	1,094	465	1,888		468
Germany	2,503	2,384	267	270	118	1,443		70
United Kingdom	1,612	1,377	540	195	52	325		136
France	871	685	434	36	27	55		10
Ireland	573	D	15	513	24	0		D
Italy	327	285	144	23	31	42		24
The Netherlands	477	314	97	5	D	4		148
Canada	1,037	854	217	D	78	227		6
Asia and the Pacific	914	717	231	99	165	43		26
Japan	595	451	174	38	120	4		5
Singapore	87	70	1	46	24	0		7
Australia	144	122	39	6	6	D		7
Latin America	253	239	61	D	11	62		1
Brazil	149	148	21	21	7	D		*
Mexico	64	57	21	D	4	D		*
Middle East[1]	30	26	2	3	18	0		1
Africa[2]	15	13	8	2	0	*		0

* = less than $500,000; D = withheld to avoid disclosing operations of individual companies.

NOTES: Data are preliminary and include foreign direct investments of nonbank U.S. affiliates only. Data are from the Bureau of Economic Analysis; the National Science Foundation estimates that R&D performed abroad for U.S. companies and their foreign affiliates totaled $8.7 billion in 1991.

[1] Ninety percent of the R&D total is undertaken in Israel.

[2] Eighty percent of the R&D total is undertaken in South Africa.

SOURCE: Bureau of Economic Analysis, Department of Commerce, *U.S. Direct Investment Abroad: Operations of U.S. Parent Companies and Their Foreign Affiliates* (Washington, DC: Government Printing Office, 1993).

growth in domestic R&D activities by U.S. companies (4.4 percent).[77]

Much of this foreign R&D growth was undertaken during the last half of the decade, just as U.S. firms' domestic R&D investments were falling off. As a result, foreign R&D was equivalent to 11 percent of the total industrial R&D *performance* in the United States in 1990—almost double that of its equivalent 6-percent share in 1985. Alternatively, as a percentage of total foreign and U.S. firms' industrial R&D *funding*, foreign companies accounted for 15 percent in 1990 (majority-owned affiliates accounted for 11 percent) compared to a 9-percent share in 1985. Although the R&D flows from other European countries also increased steadily over the past decade, 80 percent of this foreign funding came from five countries—Canada, the United Kingdom, Germany, Switzerland, and Japan. Japanese firms increased their R&D investment in the United States more rapidly than did companies from the other nations.

Foreign-funded research was in 1990 concentrated in three industries—industrial chemicals (funded predominantly by German and Canadian firms), drugs and medicines (mostly from Swiss and British firms), and electrical equipment (one-fourth of which came from German affiliates). These three industries accounted for three-fifths of

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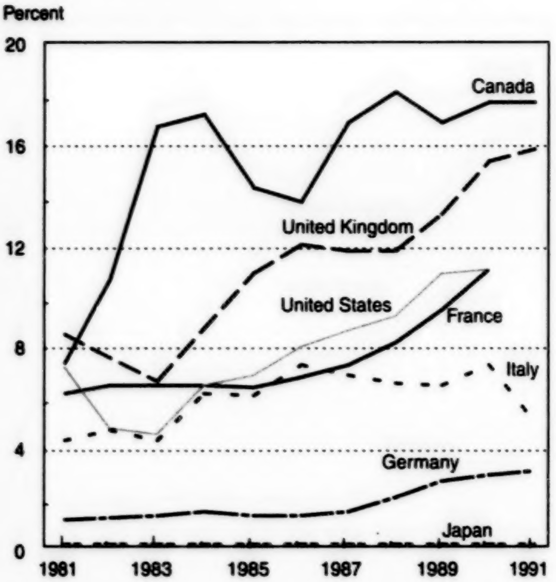
[77] BEA considers *all* of an investment (including R&D) to be foreign if 10 percent or more of the investing U.S.-incorporated firm is foreign-owned. These R&D expenditures are reported in appendix table 4-43. Special tabulations were prepared by BEA to reveal R&D expenditures in the United States of those firms in which there is majority foreign ownership—i.e., 50 percent or more. For 1990, the 10-percent foreign ownership threshold results in an estimated $11.3 billion foreign R&D investment total. R&D expenditures of majority-owned U.S. affiliates of foreign companies were $8.4 billion.

Funding trends of these two groupings are quite similar. From 1980 to 1990, inflation-adjusted R&D spending of majority-owned foreign firms was up 350 percent, whereas that of firms with 10 percent or more foreign ownership (including majority-owned firms) rose slightly more, 370 percent. See appendix table 4-45.

Figure 4-29.
Portion of industry domestic R&D performance financed from foreign sources, by country



NOTES: For United States, foreign expenditures are from companies with at least 10-percent foreign ownership. German data are for the former West Germany only.

See appendix table 4-43. *Science & Engineering Indicators – 1993*

Foreign-funded research was in 1990 concentrated in three industries—industrial chemicals (funded predominantly by German and Canadian firms), drugs and medicines (mostly from Swiss and British firms), and electrical equipment (one-fourth of which came from German affiliates). These three industries accounted for three-fifths of total 1990 foreign R&D investment—$11.3 billion. (See text table 4-7 and appendix tables 4-43 and 4-44.)

Concurrent with the rapid growth in foreign R&D expenditures in the United States, the establishment of R&D facilities here by foreign companies has accelerated. According to a recent survey (Dalton and Serapio 1993), there were 255 foreign-owned free-standing R&D facilities in the United States in 1992. About half of these had been established during the previous 6 years.[78] Other significant findings of this study follow.

- R&D facilities of Japanese firms outnumber those of all other countries combined. Japanese companies

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[78] These counts are for only those facilities (R&D center, R&D company, or R&D laboratory) that are 50-percent or more owned by a foreign parent company. An R&D facility typically operates under its own budget, and is located in a *free-standing* structure outside of and separate from the other U.S. facilities (e.g., sales and manufacturing facilities) of the parent. This definition of an R&D facility consequently excludes R&D departments or sections within U.S. affiliates of foreign-owned companies.

Text table 4–7.
R&D performed in the United States by affiliates of foreign companies, by selected country and industry of affiliate: 1990

		Manufacturing					
Country	All industry	Total manufacturing	Drugs and medicine	Other chemicals	Machinery	Electrical equipment	Instruments
	Millions of dollars						
Total	11,324	9,737	2,375	2,808	1,138	1,839	371
Europe	7,412	6,328	2,117	1,432	518	1,162	309
United Kingdom	1,864	1,639	766	193	163	131	103
Germany	1,754	1,649	[924]		50	477	79
Switzerland	1,657	1,457	1,098	15	[190]		79
France	810	724	D	D	[292]		25
The Netherlands	805	510	*	D	1	D	*
Canada	1,955	1,910	*	D	9	D	21
Asia and the Pacific	1,497	1,197	[133]		601	161	2
Japan	1,215	921	[129]		471	112	D
Latin America	381	D	D	*	3	*	*
Middle East	26	D	5	1	6	D	0
Africa	51	D	0	0	2	0	1

NOTES: Includes R&D of affiliates in which the foreign parent owns 10 percent or more of the voting equity. Majority-owned affiliates of foreign companies spent $8.4 billion on R&D performed in the United States in 1990. * = less than $500,000; D = withheld to avoid disclosing operations of individual companies.

SOURCE: Bureau of Economic Analysis, Department of Commerce, *Foreign Direct Investment in the United States: Operations of U.S. Affiliates of Foreign Companies* (Washington, DC: Government Printing Office, 1992).

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Text table 4–8.
Number of foreign R&D facilities located in the United States, by selected industry and country: 1992

Industry	Total	Japan	Germany	United Kingdom	France	South Korea	Switzer-land	Other
Biotechnology	74	17	12	13	11	0	11	10
Automotive	41	30	7	0	0	3	0	1
Computers	27	20	3	0	0	4	0	0
Software	24	21	2	0	0	1	0	0
Semiconductors	24	18	2	0	0	3	0	1
Telecommunications	22	14	3	0	0	1	0	4
Opto-electronics	11	8	3	0	0	0	0	0
High-definition TV	9	7	1	0	1	0	0	0
Medical equipment	3	1	2	0	0	0	0	0

SOURCE: D.H. Dalton and M.G. Serapio, Jr., *U.S. Research Facilities of Foreign Companies* (Washington, DC: Department of Commerce, Technology Administration/Japan Technology Program, 1993).

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- The activities of these foreign facilities were highly concentrated in the biotechnology (74 facilities), automotive (41), computers (28), and computer software (26) industries.
- Foreign R&D facilities are heavily concentrated in some areas of the country, notably California's Silicon Valley and greater Los Angeles; Detroit; Boston; Princeton, New Jersey; and Research Triangle Park, North Carolina.

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Chapter 5
Academic Research and Development: Financial Resources, Personnel, and Outputs

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HIGHLIGHTS

FUNDING FOR ACADEMIC R&D

- **The 1980s and early 1990s saw a continuation of a trend—observed over the last several decades—toward an increasing role for academic performers in total U.S. research and development (R&D).** From 1980 to 1993, academic performance rose from just above $6 billion to an estimated $20.6 billion (in current dollars), increasing from a 9.8-percent share to a 12.8-percent share of total U.S. R&D performance.

- **During the 1980-93 period, average annual growth was much stronger for the academic sector than for any other R&D-performing sector,** an estimated 5.2 percent, compared to around 2 or 3 percent for federal, industrial, and nonprofit labs. This trend has continued in recent years: Average annual growth for the academic sector between 1991 and 1993 was again estimated at 5.2 percent.

- **The federal share of academic R&D support has continued to decline as other support sources have outpaced its growth rate.** In 1993, federal sources provided an estimated 55.5 percent of academic R&D support, down from 67.5 percent in 1980. In constant dollars, however, academic R&D financed by federal support increased by 59.4 percent during this same period.

- **After the Federal Government, the academic institutions that performed the R&D provided the second largest share of academic R&D support.** From 1980 to 1993, the institutional share grew from 13.8 percent to an estimated 20.2 percent of academic R&D expenditures.

- **Industrial R&D support to academic institutions has grown more rapidly than support from other sources in recent years.** In constant dollars, academic R&D financed by industry increased by an estimated 265 percent from 1980 to 1993. Industry's share grew from 3.9 percent to an estimated 7.3 percent during this period.

- **There has been a significant increase in the number of universities and colleges receiving federal R&D support during the past two decades.** In 1991, 759 academic institutions received R&D support from the Federal Government, compared to 565 in 1971.

FACILITIES AND INSTRUMENTS

- **Construction projects initiated between 1986 and 1991 are expected to produce over 32 million square feet of new research space and over 33 million square feet of renovated research space when completed.** Both the new and repaired/renovated space will exceed the equivalent of a quarter of existing space.

- **The amount, adequacy, and condition of S&E research space at the Nation's research-performing institutions are all reported as having increased or improved between the 1988-89 and 1992-93 periods.** However, 34 percent of the institutions still reported that the amount of their research space was inadequate in 1992-93.

- **The country's U.S. research universities have recently begun to show a decline in expenditures from current funds on academic R&D instrumentation.** This decline follows a pattern of large increases in investment throughout most of the 1980s. Constant dollar expenditures for academic research instrumentation averaged 7.7 percent annual growth for federal support and 10.4 percent for nonfederal support between 1982 and 1989. In recent years this trend has reversed, with federal support declining by 5.5 percent and nonfederal support by 1.5 percent overall between 1989 and 1991.

CHARACTERISTICS OF DOCTORAL RESEARCHERS IN ACADEMIC R&D

- **The rapid increase in the number of doctoral academic researchers, evident throughout the 1980s, appears to have leveled off for all fields but the computer sciences.** Total employment between 1989 and 1991 was stable for most natural science fields and may have declined somewhat for the social sciences and psychology.

- **The aging of the academic research workforce appears to be reversing.** In 1973, only 25 percent of academic researchers had earned their Ph.D. more than 15 years earlier; this fraction was 47 percent by 1989, but dropped to 43 percent by 1991. Scientists and engineers who had received their doctorates in the past 7 years made up a growing share of all academic researchers.

- **During the 1980s, a growing fraction of academic scientists and engineers reported being active in research. This trend, which held for most age groups in all fields, has also been slowed or arrested.** Between 1979 and 1989, the proportion of all academic doctoral scientists and engineers whose primary or secondary work activity was research rose from 67 to 78 percent. However, little change was apparent between early 1989 and late 1991.

WOMEN AND MINORITIES IN ACADEMIC R&D

- **The number of doctoral women scientists and engineers employed in academia more than doubled from 1979 to 1991, and the number active in academic R&D almost tripled.** In 1991, women represented 19 percent of all doctoral academic researchers; almost half of female researchers were active in the life sciences.
- **The overall number of black, Hispanic, and Native American researchers remains low.** In 1991, these minority groups accounted for 5 percent of academic doctoral researchers, up from 2 percent in 1979. Their increasing share among researchers is roughly in line with their growing share of academic employment.
- **Asians are increasingly prominent in academic R&D.** Asians constituted 10 percent of academic researchers in 1991, up from 4 percent in 1979—an increase roughly proportional to their overall academic employment growth.

SUPPORT OF ACADEMIC RESEARCH PERSONNEL

- **Another trend showing signs of slowing or reversing is the rising proportion of academic researchers receiving federal support.** During the 1980s, an increasing fraction of researchers in all fields, except the social sciences, received such support. But from 1989 to 1991, the proportion of researchers with Federal Government support remained stable or declined for most fields.

OUTPUTS OF ACADEMIC R&D

- **U.S.-based authors continue to account for 35 percent of all publications in a set of about 3,500 major U.S. and international technical journals.** This proportion represents a modest 1 percentage point loss of world share since 1981, following a gradual decline during the 1970s. However, stronger gains and losses were experienced over the decade in specific fields and specialties, notably losses of 3 to 5 percentage points in engineering/technology and clinical medicine.
- **An increase in international coauthorship is evident in every major field and for most countries**. About 11 percent of the world's articles were coauthored internationally, double the percentage of a decade earlier.
- **In the United States, there is increasing coauthorship of articles produced by industry-based scientists and engineers with those in academia.** In 1991, about 35 percent of these articles had university researchers as coauthors, up from 22 percent a decade earlier.
- **Patenting by U.S. universities continued its rapid increase into 1991.** In 1991, 1,324 patents were awarded to U.S. academic institutions, compared with 437 a decade earlier. The strongest growth occurred in health- and biomedical-related areas.
- **The largest research universities continued to account for a large and growing share of all academic patents.** However, the 20 largest institutions (by total research volume) and those below rank 100 are receiving a declining share of academic patents, while those ranking 21 to 100 have been gaining share, due to the more rapid growth of patenting activity in this segment.

Introduction

Chapter Background

Academic research and development (R&D) is an integral part of the national R&D enterprise. The sector now accounts for an estimated 12.8 percent of national R&D expenditures and more than half of national basic research expenditures. This chapter addresses the following three principal aspects of academic R&D:

- *financial resources:* sources of funding, distribution among institutions and disciplines, the Federal Government's funding role, the spreading institutional base of federally financed academic R&D, and the financing of academic R&D facilities and instrumentation;
- *doctoral personnel:* characteristics of doctorate-level scientists and engineers employed by academic institutions; and
- *research outputs:* the academic sector's publications and patents.

Chapter Organization

The chapter opens with a discussion of trends in financial resources provided for academic R&D, including allocations across both institutions and fields. Since the Federal Government has been the primary source of support for academic R&D for over half a century, its role is explored in greater detail. For the first time in the *Science & Engineering Indicators* series, data are presented on changes in the number of academic institutions receiving federal R&D support. Another new item is a brief discussion of changes in the modes of federal research support to academic institutions over the past decade. Also, due to an increasing interest in and support for expanded university-industry interactions, the section includes a focused examination of growth in industrial funding of academic R&D. Finally, data are included on funding trends for two key elements of university infrastructure—facilities and instrumentation.

The second section of the chapter covers the academic R&D workforce. It focuses on doctoral scientists and engineers working in science and engineering (S&E) who earned their doctorates at U.S. institutions. Trends in the growth of various disciplines and in the numbers of women and minorities in academic R&D fields are addressed. Also presented are new information about the changing age structure of academic researchers, the trend toward increased research participation in academia, and the extent of federal support provided to academic doctoral researchers. Included for the first time is a discussion of changes in the number and percentage of federally supported academic researchers receiving support from multiple—as opposed to from a single—federal agency. The section also includes a brief discussion of the number of graduate students involved as research assistants in academic R&D.

The chapter's final section discusses the outputs of academic R&D, specifically the number, subjects, and authors of articles published in scientific and technical journals worldwide; and trends in the number of patents issued to U.S. universities.

Financial Resources for Academic R&D

This section focuses on the levels and sources of support for R&D activities at U.S. universities and colleges.[1] Beginning with an examination of the role of academic R&D in the context of the national R&D system, it covers R&D funding patterns in terms of funding sources and their distribution among academic institutions and across S&E fields. The role of both industry and the Federal Government in supporting R&D at universities and colleges is explored in some detail. Specifically, data are presented on the increase in the share of academic R&D support provided by industry, the expansion in the number of academic institutions receiving federal support, and the changing modes of federal R&D support. Aspects of academic R&D facilities and instrumentation, including the levels of investment made in these during the 1980s and characteristics of both the facilities and instrumentation stock, are also examined.

Academic R&D in a National Context[2]

In 1993, an estimated $20.6 billion was spent for R&D at U.S. academic institutions.[3] This level of expenditure represents a continuing trend, observed over the last several decades, of an increasing role for academic performers in total U.S. R&D. Academic R&D in 1993 made up an estimated 12.8 percent of total R&D, compared with about 10 percent in 1980 and about 9 percent in 1970. During the 1970-93 period, the proportion of total U.S. research[4] expenditures in academic institutions rose from 24 percent to an estimated 28.6 percent. (See figure 5-1.)

In constant 1987 dollars, average annual R&D growth between 1980 and 1993 was much stronger for the academic sector than for any other R&D-performing

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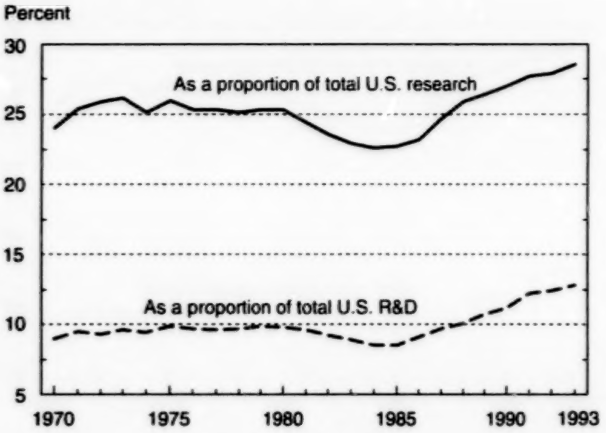
[1] Data in this section come from several different National Science Foundation (NSF) surveys; these do not always use comparable definitions or methodologies. NSF's three main surveys involving academic R&D are (1) the Federal Funds for Research and Development Survey; (2) the Federal Support to Universities, Colleges, and Selected Nonprofit Institutions Survey; and (3) the Scientific and Engineering Expenditures at Universities and Colleges Survey. The results from this last are based on data obtained directly from universities and colleges; the former two surveys collect data from federal agencies. For descriptions of the methodologies of these and selected other NSF surveys, see SRS (1987).

[2] This discussion is based on data in SRS (1992b) and unpublished tabulations. For more information on national R&D expenditures, see chapter 4, "National R&D Spending Patterns."

[3] In this section, academic institutions generally comprise institutions of higher education that grant doctorates in science or engineering and/or spend at least $50,000 for separately budgeted R&D. Federally funded research and development centers associated with universities are tallied separately and are examined in greater detail in chapter 4.

[4] Includes basic research and applied research.

Figure 5-1.
Academic R&D and research as a proportion of U.S. totals



NOTES: Academic research includes basic research and applied research. Data for 1992 and 1993 are estimates.

See appendix tables 4-4, 4-5, and 4-6.

Science & Engineering Indicators – 1993

sector—an estimated 5.2 percent, compared to about 3.1 percent for federally funded research and development centers (FFRDCs) and other nonprofit laboratories, 3 percent for industrial laboratories, and 1.7 percent for federal laboratories. The rate of growth for academic R&D from 1992 to 1993 is estimated at 5.3 percent, which is basically the same average annual growth rate this sector has maintained since 1980. As a proportion of the gross domestic product, academic R&D rose significantly between 1980 and 1993, from 0.22 to 0.33 percent.

Academic R&D activities are concentrated at the research (basic and applied) end of the R&D spectrum and do not include much development activity.[5] Of 1993 academic R&D expenditures, an estimated 66 percent went for basic research, 26 percent for applied research, and 8 percent for development. (See figure 5-2.)

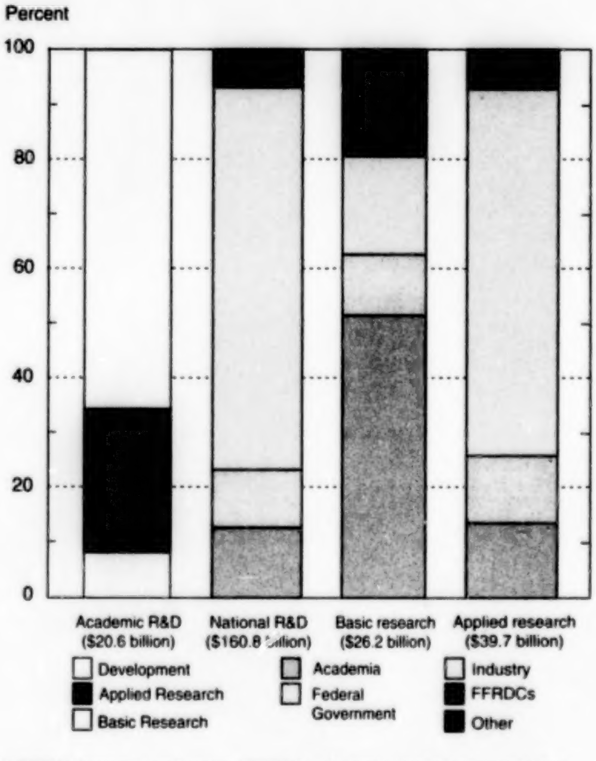
Sources of Funds

The Federal Government continues to provide the majority of funds for academic R&D, but participation by other sectors has been growing more rapidly than that of the Federal Government in recent years. This circumstance has resulted in a decline in the federal share of academic R&D. (See figure 5-3.)

In 1993, the Federal Government provided an estimated 55.5 percent of the funding for R&D performed in academic institutions, down from 67.5 percent in 1980, and 70.5 percent in 1970. Following is a discussion of the contributions to academic R&D made by the other sectors.

- *Institutional funds:* Institutional funds are separately budgeted funds an academic institution spends on R&D, including unreimbursed indirect costs associated with R&D projects financed by outside organizations and mandatory cost sharing on federal and other grants. These are the second largest source of academic R&D funds. From 1980 to 1993, the institutional share grew from 13.8 percent to an estimated 20.2 percent of all academic R&D expenditures. The major sources of institutional funds are (1) general-purpose state or local government appropriations, (2) general-purpose grants from industry, (3) tuition and fees, and (4) endowment income.[6] There is some concern that part of the

Figure 5-2.
National and academic R&D expenditures, by character of work and performer: 1993



NOTES: Data are estimates. FFRDC = federally funded research and development center.

See appendix tables 4-4, 4-5, 4-6 and 5-1.

Science & Engineering Indicators – 1993

increase in the importance of institutional funds is due to accounting changes.

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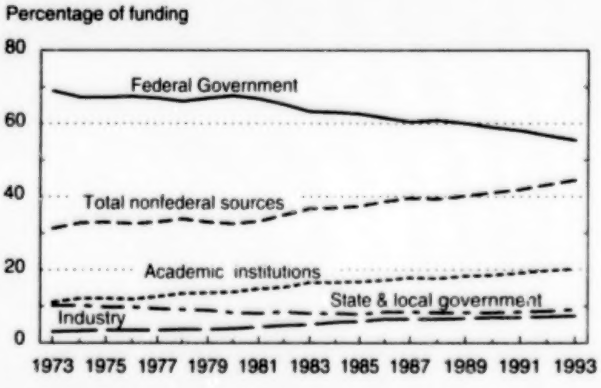
[5] Notwithstanding this delineation, "R&D"—rather than just "research"—is used throughout this discussion, since almost all of the data collected on academic R&D do not differentiate between "R" and "D."

[6] Another potential source of institutional funds is income from patents or licenses. See "Income From Patenting and Licensing Arrangements" later in this chapter for a discussion of this subject.

- *State and local government funds:* The share of academic R&D funding provided by state and local government has remained constant over the past decade at about 8 or 9 percent. This share, however, only reflects funds *directly* targeted to academic R&D activities, and consequently understates the total contribution of state and local governments.
- *Other sources of funds:* Other sources of support include grants for R&D from nonprofit organizations and voluntary health agencies, as well as all other sources not elsewhere classified. Between 1990 and 1993, this source of academic R&D support increased from about 7 percent to an estimated 8 percent.
- *Industry funds:* The funds provided by the industrial sector for academic R&D grew faster than did funding from any other source during the past two decades. Industry increased its share from 3.9 percent in 1980 to an estimated 7.3 percent in 1993. Moreover, industry's contribution to academia represented about 1.8 percent of all industry-funded R&D in 1993, compared to 0.8 percent in 1980, and 0.6 percent in 1970.

Patterns of sectoral funding of academic R&D vary depending on the type of academic institution involved. That is, private and public universities differ in their major sources of R&D support. (See appendix table 5-3.) For ***public*** academic institutions, just over 11 percent of R&D funding in 1991 came from state and local funds and about 24 percent from institutional funds. ***Private*** academic institutions received only 2.5 and 10 percent of their funding, respectively, from these sources. Between 1981 and 1991, the federal share of support declined for both public and private institutions, dropping from 60 to 51 percent for public institutions and from 79 to 71.5 percent for private institutions. Both public and private institutions received approximately 7 percent of their respective R&D support from industry in 1991.

Figure 5-3.
Sources of academic R&D funding, by sector



NOTE: Data for 1992 and 1993 are estimates.

See appendix table 5-2. *Science & Engineering Indicators – 1993*

Distribution of R&D Funds Across Academic Institutions

Most academic R&D is now, and has been historically, concentrated in relatively few of the 3,600 higher education institutions in the United States.[7] In fact, if all such institutions are ranked by their 1991 R&D expenditures, the top 200-ranked institutions account for 96 percent of R&D expenditures. In 1991,

- the top 10 institutions spent 18 percent of total academic R&D funds ($3.062 billion);
- the top 20 institutions spent 32 percent ($5.430 billion);
- the top 50 spent 57 percent ($9.878 billion); and
- the top 100 spent 81 percent ($13.953 billion).[8] (See appendix table 5-4.)

Industrial Support of R&D at Specific Academic Institutions

Industry now supports over 7 percent of total academic R&D. While most of the industrial funds go to large, recognized research institutions, about a dozen academic institutions with relatively small R&D expenditures get more than 20 percent of their R&D funding from industry. These funding patterns partly reflect relationships that have developed between individual firms and schools.

In 1991, industry provided just over $1.2 billion for academic R&D. Of the top 200 institutions in terms of total 1991 academic R&D expenditures, the top 25 schools together received almost $409 million from industry, or about 33 percent of the total support contributed by industry. The bottom 25 schools received $38 million, or 3.1 percent of total industry funds. On average, the top 25 schools received $16.4 million each in industrial support; the lowest 25 schools averaged $1.6 million each. (See appendix table 5-5.)

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[7] The Carnegie Foundation for the Advancement of Teaching classified 3,600 degree-granting institutions as higher education institutions in 1987. (See chapter 2, "Classification of Academic Institutions," for a brief description of the Carnegie categories.) These higher education institutions include 4-year colleges and universities, 2-year community and junior colleges, and specialized schools such as medical and law schools. Not included are more than 7,000 other postsecondary institutions (secretarial schools, auto repair schools, etc.).

[8] These percentages exclude the Applied Physics Laboratory (APL) at Johns Hopkins University. With an estimated $439 million in total and $430 million in federally financed R&D expenditures in fiscal year 1991, APL performs about two-thirds of the university's R&D. Although not officially classified as an FFRDC, APL essentially functions as one. Its exclusion therefore provides a better measure of the distribution of academic R&D dollars and the ranking of individual institutions.

Text table 5–1.
Industrial funding of academic R&D, by level of R&D expenditures

Schools ranked by total R&D expenditures[1]	Schools w/more than 10% of their total R&D funds from industry		Average proportion of total R&D funding from industry	
	1980	1991	1980	1991
	Number		Percent	
Rank 1–200	24	57	4.6	8.6
1–25	2	4	4.4	6.3
26-50	2	3	4.4	6.4
51–75	2	2	3.8	6.2
76–100	1	4	4.6	6.6
101–125	3	12	5.5	9.4
126–150	4	9	5.9	10.0
151–175	2	11	5.6	10.0
176–200	8	12	11.4	13.5

NOTE: Data are omitted for those institutions that did not separately report industrial R&D funding or that reported no industrial support. For 1980, 32 institutions were omitted; 6 were omitted in 1991.

[1] Ranking is derived by sorting institutions into groups of 25, from highest R&D expenditures to lowest.

See appendix table 5–5. *Science & Engineering Indicators – 1993*

This distribution of industry funds follows an expected pattern: Top-ranked schools receive more industry funding than do lower ranked schools. A more surprising finding is that industry's share of total R&D expenditures for the lowest ranked schools was double its corresponding share among top-ranked schools. Industry accounted for an average 13.5 percent of the total R&D expenditures of schools in ranks 176-200 in 1991, compared with a 6.3 percent share of total for the top 25 schools. Furthermore, the low-ranked schools receiving relatively large proportions of their R&D funding from industry tend to be specialized smaller institutions—frequently ones with a single R&D specialty that is closely linked with local industry.

Between 1980 and 1991, the number of schools receiving over 10 percent of their academic R&D support from industry increased from 24 to 57. In all but one of the eight groups of 25 among the top 200 research institutions, the *number* of institutions receiving more than 10 percent of their academic R&D support from industry increased (it did not change in the schools in ranks 51-75). The *share* of funds from industry also increased in each of the eight groups.

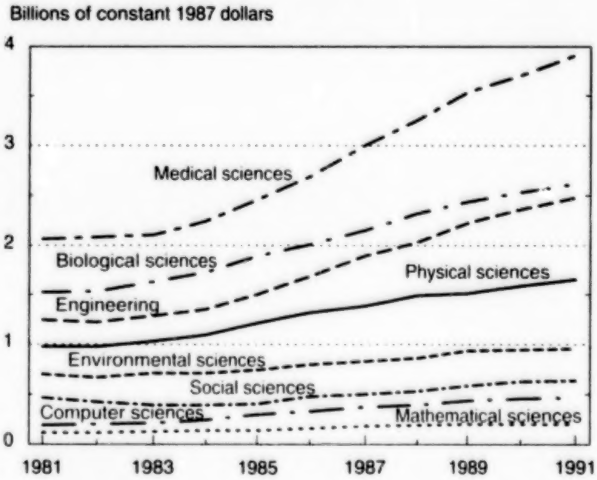
Several factors might contribute to these increases. For one thing, more institutions had separately reported industrial support data in 1991 than in 1980. (See text table 5-1.) Also, the increasing industry support for academic R&D may reflect increasing amounts of cooperative research activity between the two sectors, in contrast to companies just providing research grants to universities and colleges.

Academic R&D Expenditures by Field and Funding Source[9]

By far, the majority of academic R&D expenditures in 1991 went to the *life sciences*, which accounted for 54 percent of total academic R&D expenditures, 53 percent of federal academic R&D expenditures, and 55 percent of nonfederal academic R&D expenditures. The next largest block of total academic R&D expenditures was for *engineering*—16 percent in 1991.[10] (See appendix table 5-6; for detailed data on expenditures over time by S&E subfield, also see appendix table 5-7.)

Between 1981 and 1991, academic R&D expenditures for all fields combined grew at an average annual rate of 5.5 percent in constant 1987 dollars. (See figure 5-4 for constant dollar expenditures over the decade by field.) Funding for the *computer sciences* grew fastest during the decade, increasing at an average annual rate of 9.7 percent in constant dollars. However, R&D expenditures for the computer sciences in 1991 were only about 3.1 percent of total academic R&D. The ***engineering*** and ***mathematical sciences*** fields grew second and third fastest during the decade, increasing at average annual rates of 7.1 and 5.8 percent, respectively. Academic R&D

Figure 5-4.
Academic R&D expenditures, by field



NOTE: See appendix table 4-1 for GDP implicit price deflators used to convert currrent to constant 1987 dollars.

See appendix table 5-7. *Science & Engineering Indicators – 1993*

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[9] The data in this section are drawn from the National Science Foundation's Scientific and Engineering Expenditures at Universities and Colleges Survey. For various methodological reasons, parallel data by field from the Foundation's Survey of Federal Obligations to Universities and Colleges do not necessarily match these numbers.

[10] For further information on the nature of engineering research being performed in U.S. universities see "The Nature of Engineering Research at U.S. Universities."

The Nature of Engineering Research at U.S. Universities

What is the role of research in engineering education? How does this academic research component relate to the needs and interests of U.S. industry and government? To answer these and related questions, a 3-year study on the nature of U.S. academic engineering research is now under way. Led by Professor Robert P. Morgan of Washington University and supported by the National Science Foundation, the study is aimed at characterizing the research undertaken by U.S. engineering school faculty members, research staff, and students (Morgan et al. 1993a and 1993b). As part of this study, a national survey of directors of organized university-based engineering research units was conducted to obtain information on the nature, process, and outcomes of engineering school research. To date, responses have been received from 651 of 1,030 of these research units located in 154 universities. Based on these responses, the following preliminary conclusions have been drawn.

- Research units appear to be shifting away from the individual investigator model of research toward more applied team research of a cross disciplinary nature. Despite this shift, traditional research outputs such as publications and papers still predominate.
- Students continue to play a central role in research.
- Industry is substantially involved in university-based engineering research.
- The most frequently cited problems of research directors are insufficient funding and lack of funding for long-term research.
- Contributions of research units vary widely from those of a fundamental nature to activities leading to major developments in industry and government.

Followup will be conducted regarding this last finding in order to develop case studies of academic research contributions and the processes by which technology transfer takes place. Also, a national survey will be mailed to about 3,500 of the roughly 20,000 U.S. engineering faculty during the fall of 1993 to complement the research directors' survey.

expenditures in the *social sciences* grew the slowest, averaging 3.1 percent.

The distribution of federal and nonfederal funding of academic R&D in 1991 varied by field and subfield. (See appendix table 5-6.) For example, the Federal Government supported 62 percent of academic R&D expenditures in the medical sciences subfield, but only 26 percent of academic R&D in the agricultural sciences subfield. (This latter figure reflects the traditionally strong role of states in supporting the agricultural sector.)

It is noteworthy that the declining federal share in the support of academic R&D is not limited to particular S&E disciplines. Rather, the federally financed fraction of support for *each* of the S&E fields declined over the past two decades. (See appendix table 5-8.) There were some variations by field, however. The most dramatic decline occurred in the social sciences (57 percent in 1973 to 33 percent in 1991); the smallest decline was in the computer sciences (70 to 67 percent). The overall decline in federal share also holds for all reported S&E subfields.

Support of Academic R&D by Federal Agencies[11]

Federal obligations for academic R&D are concentrated in three agencies: the National Institutes of Health (NIH), the National Science Foundation (NSF), and the Department of Defense (DOD). Together, these agencies provided about 73 percent of total federal financing of academic R&D in 1993, up from 66 percent in 1971. (See appendix table 5-9.) NIH was estimated to have provided 44 percent of federal support for academic R&D in 1993; the NSF share was estimated at 16 percent. DOD's share was estimated at 13 percent in 1993.

During the past 10 years, the National Aeronautics and Space Administration (NASA)—which is estimated to provide less than 6 percent of federal support in 1993—had the highest estimated average annual growth in its funding of academic R&D: 9.7 percent per year (constant 1987 dollars). The next highest rates of growth were experienced by NSF (5.2 percent) and NIH (4.5 percent). In addition to changes in the pattern of agency funding, there have been shifts in the modes of research support provided to academic institutions. For details, see "Federal Academic Research Funding by Mode of Support."

The Spreading Institutional Base of Federally Funded Academic R&D[12]

In 1971, 565 academic institutions received federal support for their R&D activities. In 1981, this number

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[11] See "An Update on Congressional Earmarking to Universities and Colleges," for a discussion of an issue related to federal academic R&D support that continues to engender considerable debate.

[12] The data in this section are drawn from the Federal Support to Universities, Colleges, and Selected Nonprofit Institutions Survey. The survey collects data on federal R&D obligations to individual U.S. universities and colleges from the 15 federal agencies that account for virtually all such obligations.

An Update on Congressional Earmarking to Universities and Colleges

Science & Engineering Indicators – 1991 (NSB 1991) discussed several aspects of academic earmarking—the congressional practice of providing federal funds to educational institutions for research facilities or projects without merit-based peer review. The significant increases reported then in both the number of earmarked projects and the amount of money directed toward them are still continuing. (See text table 5-2.)

In his introduction to the recent report "Academic Earmarks: An Interim Report by the Chairman of the Committee on Science, Space, and Technology" (Committee on Science, Space, and Technology 1993), Congressman George E. Brown, Jr. (D-CA), states that

> "I believe that the rational, fair, and equitable allocation and oversight of funds in support of the Nation's research and development enterprise is threatened by the continued increase in academic earmarks. To put it colloquially, a little may be okay, but too much is too much."

As text table 5-2 shows, the number of academic earmarks has increased from a negligible level in the early 1980s to hundreds of earmarks in the past few years; the dollar amount of these earmarks has increased from the tens to the hundreds of millions.

Text table 5–2.
Growth in number of and funds for earmarked academic projects

	Number of earmarks	Dollars for earmarks
1980	7	10,740,000
1981	0	0
1982	9	9,370,999
1983	13	77,400,000
1984	6	39,320,000
1985	39	104,085,000
1986	38	110,885,000
1987	48	163,305,000
1988	72	232,392,000
1989	208	299,026,000
1990	252	247,976,333
1991	279	470,279,499
1992	499	707,989,031

SOURCE: Committee on Science, Space, and Technology, U.S. House of Representatives, "Academic Earmarks: An Interim Report by the Chairman of the Committee on Science, Space, and Technology," Washington, DC: 1993.

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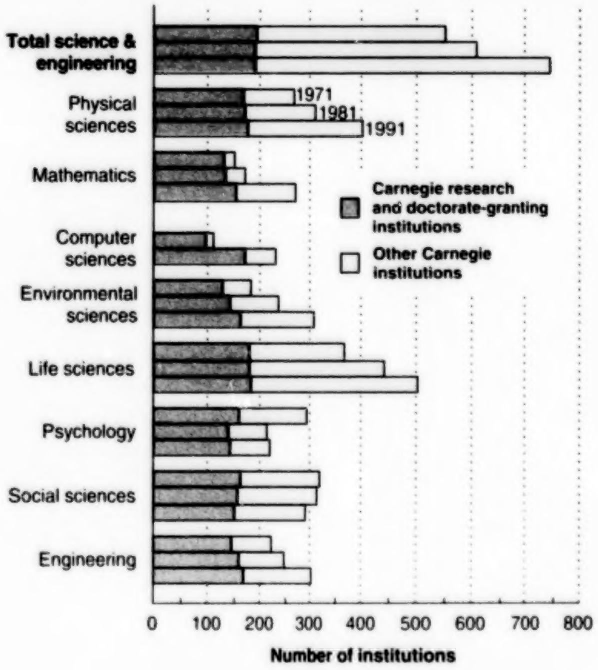
increased to 618, and by 1991, to 759. (See appendix table 5-10.) During this 20-year period, however, there was almost no change in the number of Carnegie research or doctorate-granting institutions receiving federal R&D obligations. Instead, almost all of the increase in the number of institutions supported occurred in the other Carnegie classifications—i.e., among comprehensive; liberal arts; 2-year community, junior, and technical; and professional and other specialized schools.[13]

This spreading of the institutional base of federally funded academic R&D did not occur at the same rate, nor even in the same direction, in all science and engineering fields. Once again, at the individual field level, most of the increase was at institutions other than research or doctorate-granting ones. The largest relative increases in the number of institutions receiving academic R&D support from the Federal Government were in the computer sciences, mathematics, and geological sciences. Two fields—the social sciences and psychology—showed a decline in the number of institutions receiving federal academic R&D support. (See figure 5-5.)

Figure 5-5.
Academic institutions receiving federal R&D support



NOTES: "Other Carnegie institutions" are all Carnegie-classified institutions except research and doctorate-granting institutions. No data are available for 1971 for the computer sciences.

See appendix table 5-10. *Science & Engineering Indicators – 1993*

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[13] See chapter 2, "Classification of Academic Institutions," for a brief description of the Carnegie categories.

Federal Academic Research Funding by Mode of Support

Until recently, very little data were available on trends in federal funding of academic research by mode of support. This changed, however, with the release of ***Trends in the Structure of Federal Science Support*** by the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET). The report (OSTP 1992) defined four principal modes of support, and primarily examined civilian federal research funding from six agencies—the Department of Energy (DOE), NIH, NSF, Environmental Protection Agency (EPA), Department of Agriculture (USDA), and NASA. (DOD was also included in some of the discussions.)

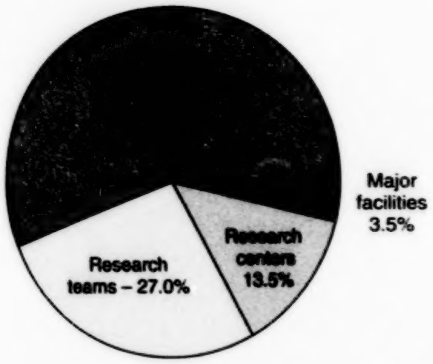
Definitions. FCCSET used the following definitions of support modes.

- ***Individual investigator:*** A single senior scientist or small research group receiving direct funding for an independent research project.
- ***Research team:*** A group of senior investigators, often at different institutions, pursuing common research objectives and considered by the funding agency to be a team. A research team is less formally organized than a research center and may be funded separately.
- ***Research center:*** A formally organized group of investigators, frequently multidisciplinary, using shared resources to pursue coordinated research focused on a single topic or research theme.
- ***Major facility:*** A large multi-user laboratory or research facility requiring a long-term commitment for support. A major facility is intended for shared used by researchers from many institutions, and is frequently designated as "national" or "regional" in scope.

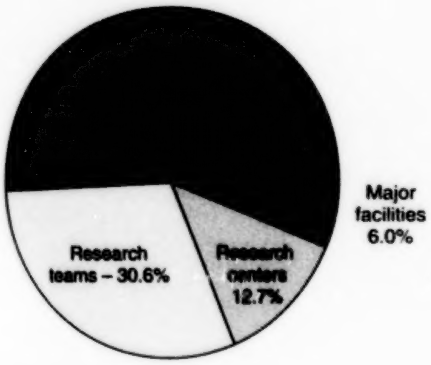
Findings. FCCSET found that funding has increased for all modes of support, albeit at different rates. Overall, the shares of research funds going to individual investigators and to research centers declined between 1980 and 1989, while the shares to research teams and major facilities increased. (See figure 5-6.)

The distribution of academic research funds among modes of support differs substantially across the six agencies examined. For example, while individual investigators account for a major share of each agency's academic research support, there are significant differences by agency. Individual investigators receive between 60 and 80 percent of funding by NSF, EPA, and DOD; they receive about 50 percent of NIH funding, and account for only about 35 to 40 percent of USDA and DOE funding. In USDA, research centers play a much more crucial role in academic research funding; in DOE, research teams, research centers, and major facilities also receive significant support. NIH has given increasing attention to interdisciplinary research during the 1980s, with the result of stimulating awards to team research.

Figure 5-6.
Funding of academic research by six civilian federal agencies, by support mode



FY 1980



FY 1989

Research funding: FY 1989

Agency	All modes	Ind. invest.	Res. team	Res. center	Major. fac.
	Millions of dollars				
NIH	4,445	2,171	1,752	484	38
NSF	1,438	885	164	112	277
DOE	560	230	168	91	72
USDA	356	129	2	193	32
NASA	404	216	133	27	19
EPA	59	47	0	12	0

See appendix table 4-20. *Science & Engineering Indicators – 1993*

Academic R&D Facilities and Instrumentation[14]

Despite increased and prolonged spending in this area since the 1980s, problems persist in the amount and adequacy of academic research facilities and instrumentation. Recent surveys indicate, however, that these increases in expenditures are addressing at least some of the needs in these areas.

Facilities. Although new facilities construction projects have become more expensive, construction costs appear to be leveling off. The cost of new academic R&D space in current dollars was $207 per square foot in 1986-87,[15] $231 in 1988-89, and $260 in 1990-91. The comparable cost for 1992-93 is estimated at $259 per square foot. (See appendix table 5-11.) Similarly, construction outlays for academic research facilities are expected to reach $3.2 billion (in current dollars) in 1992-93; this is up from $3.0 billion in 1990-91, $2.5 billion in 1988-89, and $2.1 billion in 1986-87.

When the projects initiated between 1986 and 1991 are completed, they are expected to produce over 32 million square feet of new research space—the equivalent of about 26 percent of existing research space. The total amount of research space has not been increasing as much as the planned new construction, suggesting that the new research space may replace obsolete or inadequate space rather than add to existing space. The new construction projects initiated in 1992-93 should produce over 12 million square feet of new research space. (See appendix table 5-12.)

Outlays for major repair/renovation of academic research facilities are expected to reach $895 million (in current dollars) in 1992-93, compared to $835 in 1990-91, $1,010 in 1988-89, and $838 in 1986-87. When the repair/renovation projects initiated between 1986 and 1991 are completed, they are expected to result in the repair/renovation of over 33.5 million square feet of research space, the equivalent of about 28 percent of existing research space. New projects initiated in 1992-93 are expected to result in the repair/renovation of an additional 6 million square feet of research space. (See appendix table 5-12.)

More than 85 percent of current academic research space is concentrated in five S&E fields:

- biological sciences (23 percent)
- medical sciences (18 percent),
- agricultural sciences (16 percent),
- engineering (15 percent), and
- physical sciences (13 percent).

Text table 5–3.
Condition of academic science and engineering research facilities

Condition of research facilities	1988	1990	1992
	Percentage of institutions' S&E research space		
Suitable for use in most scientifically sophisticated research	23.9	25.9	26.8
Effective for most uses, but not most scientifically sophisticated	36.8	35.2	34.7
Requires limited repair/renovation to be used effectively	23.5	23.3	22.6
Requires major repair/renovation to be used effectively[1]	15.8	15.5	12.8
Requires replacement[2]	NA	NA	3.1

S&E = science and engineering

NOTES: Because of rounding, components may not add up to 100.

[1] The data for 1988 and 1990 in this category include space requiring replacement.

[2] This category was first used in the 1992 survey.

SOURCE: Science Resources Studies Division, National Science Foundation, *Scientific and Engineering Research Facilities at Universities and Colleges: 1992*, NSF 92-325, Washington, DC: NSF, 1993.

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The condition of academic S&E research facilities space has improved somewhat between 1988 and 1992. (See text table 5-3.) Specifically, the amount of space available for use in the most scientifically sophisticated research has increased; and the amount of space that needs limited repair/renovation has decreased.

A significant improvement of institutions' assessment of the amount of research space also occurred between 1988 and 1992. In 1988 and 1990, 40 to 42 percent of institutions reported that their space was inadequate, compared to only 34 percent in 1992.

Although the increased facilities funding has been beneficial to the academic research infrastructure, survey results indicate that respondents believe there is still a construction backlog as well as considerable space that needs renovation and repair.

Instrumentation. Current fund expenditures for academic research instrumentation grew steadily between 1982 and 1989 before beginning to decline in 1990 and again in 1991 (constant dollars.)[16] (See appendix table 5-13.)

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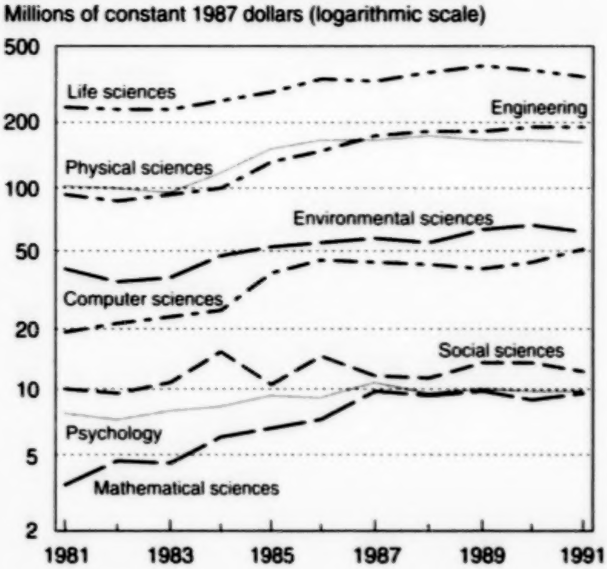
[14] Data on facilities and instrumentation are taken primarily from several surveys supported by the National Science Foundation. Although terms are defined specifically in each survey, in general, facilities expenditures (1) are classified as "capital" funds, (2) are fixed items such as buildings, (3) often cost millions of dollars, and (4) are not included within r&d expenditures as reported here. Equipment and instruments (the terms are used interchangeably) are generally movable, purchased with current funds, and included within r&d expenditures. Because the categories are not mutually exclusive, some large instrumentation systems could be classified as either facilities or equipment.

[15] Data are aggregated into 2-year units because information on project costs and net assigned square footage for repair/renovation and construction activities are requested for 2 years rather than for a single year.

[16] Data used here are limited to current funds expenditures for research instrumentation and do not include funds for instructional equipment. Current funds—as opposed to capital funds—are those in the yearly operating budget for ongoing activities. Generally, academic institutions keep separate accounts for current and capital funds.

Figure 5-7.
Current fund expenditures for research equipment at academic institutions, by field



NOTE: See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

See appendix table 5-13. *Science & Engineering Indicators – 1993*

R&D equipment expenditures grew by 3.9 percent between 1988 and 1989, and then declined by 1 percent between 1989 and 1990, and by 3 percent between 1990 and 1991. About 59 to 64 percent of these expenditures were covered by the Federal Government during the 1980s, but the government's share fell to about 59 percent in both 1990 and 1991. This percentage varied among individual fields, however, with the social sciences receiving only about one-third of their research equipment funds from the Federal Government, and the physical and computer sciences over 70 percent. In the period between 1982 and 1991, federal support did not grow as quickly as did nonfederal. Annual growth in federal support averaged 5.2 percent, while nonfederal support grew 7.8 percent (in constant dollars) during this period.

By field, current fund expenditures for instruments for engineering, computer sciences, mathematical sciences, environmental sciences, and physical sciences increased at average annual rates, in constant 1987 dollars, of between 6 and 10 percent since 1982. Funds for research equipment for the social sciences and psychology grew at an average annual rate of less than 4 percent since 1982. (See figure 5-7.)

From 1981 through 1991, annual current fund research equipment expenditures fluctuated between 6 and 7 percent of total R&D expenditures, with an upward trend in this proportion between 1983 and 1986, and a downward trend since 1986. Equipment purchases as a percentage of R&D expenditures were consistently higher than average in the computer sciences, physical sciences, and engineering; they were consistently lower in the mathematical sciences, social sciences, life sciences, and psychology.

Characteristics of Academic R&D Instrumentation.[17] As noted in *Science & Engineering Indicators –1991* (NSB 1991), the age distribution of academic research instrumentation changed significantly over the course of the first three surveys as a result of both retirement of older equipment and an increase in the size of the equipment stock. In 1982-83, 62 percent of the in-use instrument systems were 5 years old or less, and 38 percent were 6 or more years old. By 1988-89, 69 percent of the systems were 5 years old or less.

In each of the four survey cycles, annual expenditures (in constant dollars) for the purchase of research instruments increased;[18] expenditures for their repair and maintenance also increased in all but the last cycle. (See text table 5-4.) After adjustment for inflation, expenditures for purchasing new or used equipment increased by about 52 percent between 1983-84 and 1986-87 but only by 5 percent between 1989-90 and 1992.[19] Maintenance and repair expenditures increased by 31 percent between the first and second cycles and decreased by 8 percent between the third and fourth cycles. As a result of these expenditure patterns, for every dollar spent on purchasing research equipment, 25 cents was spent on maintenance and repair in 1983-84, 22 cents in 1986-87, 25 cents in 1989-90, and 22 cents in 1992.

The purchase of new equipment during the 1980s and early 1990s appears to have produced beneficial results for many academic departments and research facilities. Thirty-four percent of the S&E department heads and research facility administrators reported that the overall adequacy of their existing research equipment remained about the same, and 48 percent reported that it improved between the 1989-90 and 1992 periods. (Similar results had been

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[17] Beginning in 1983-84, NSF, with funding support from NIH, initiated the triennial National Survey of Academic Research Instruments and Instrumentation Needs. The survey's first three cycles (conducted in 1983-84, 1986-87, and 1989-90) collected data for six S&E fields, with data on half the fields collected in the survey's first year, and data for the second half in the survey's second year. For the survey's newest cycle, the two data collection phases will be consolidated so that all fields are covered at one time. Also, in previous cycles, each survey had: (1) department questionnaires requesting department expenditures for equipment plus related issues such as equipment needs and priorities; and (2) instrument data sheets for information on the condition, cost, usage, etc., of specific items of equipment. Beginning in the fourth cycle, each of these components will be conducted every other year. Thus, the 1992 component of the survey collected only the department questionnaire survey data.

[18] Expenditures for research equipment purchases obtained through this survey are not readily comparable with those discussed in the previous section. These survey data include all expenditures-both from current operating funds and capital accounts-while the earlier discussion is limited to research equipment from current funds expenditures, which could be a considerably smaller expenditure. Taken together, however, these two data sources appear to suggest that although overall expenditures for instrumentation continue to increase, expenditures financed from current funds are declining in recent years.

[19] Expenditure data for the 1983-84 to 1986-87 period and the 1989-90 to 1992 period are not comparable because the earlier years do not contain supersystems (units having a piece of equipment generally worth $1 million or more) while the later years do contain these systems.

Text table 5-4.
Annual expenditures for research equipment purchases and for maintenance of existing research equipment

	1983–84	1986–87	1989–90	1992
	Millions of constant 1987 dollars			
Purchases of nonexpendable research equipment	470	713	1,083	1,138
Maintenance/repair of existing research equipment	118	154	275	253
	Dollars			
Amount spent on maintenance/repair for each $1 spent on research equipment	0.25	0.22	0.25	0.22

NOTE: Years 1983–84 and 1986–87 do not contain supersystems (units having a piece of equipment generally worth $1 million or more), but years 1989–90 and 1992 do.

SOURCE: Science Resources Studies Division, National Science Foundation, *Academic Research Instrumentation and Instrumentation Needs in Science and Engineering: 1992* (Washington, DC: NSF, forthcoming).

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reported between the 1986-87 and 1989-90 periods.) In addition, 15 percent of S&E department heads reported that the amount of usable equipment had increased by 50 percent or more, and another 53 percent reported that it had increased by between 11 and 49 percent, between 1989-90 and 1992. However, even with the increases reported in both the adequacy of their research equipment and the amount of usable research equipment, 79 percent of respondents reported that instrument needs had increased because of expanding staff or programs or other factors.

Doctoral Scientists and Engineers Active in Academic R&D

This section discusses characteristics of academic scientists and engineers with doctorates from U.S. universities who, at the time surveyed, worked in science or engineering fields.[20] Emphasis is given to researchers—i.e., those who report that research is their primary or secondary work responsibility. This section presents data on their number and characteristics, including their fields of concentration, age, sex, race/ethnicity, and extent of federal support. A discussion is included on trends in the reported ***primary*** work responsibility (for research or teaching) of S&E doctorates in regular faculty positions. Some limited data are also presented on graduate research assistants who participate in academic R&D.

Trends in the Number and Characteristics of Academic Researchers[21]

In 1991, there were 177,805 scientists and engineers with doctorates earned at U.S. institutions working in S&E at U.S. universities and colleges.[22] (See appendix table 5-14.) Of the doctoral scientists in academia, 149,874, or 84 percent, held faculty rank, down from 88 percent in 1979 and 1981. The remainder held other positions. In all, 134,647 were engaged in academic R&D as defined here, including 76 percent of those with faculty rank and 75 percent of those with other positions.

During the 1980s, the academic doctorate-holding S&E workforce became more ***research-intensive***, as measured by the proportion of those reporting research as their primary or secondary work responsibility. Between 1979 and 1991, the number of doctoral scientists and engineers employed in academia increased by 30 percent—from 135,841 to 177,805—but the number of doctoral academic S&E researchers increased by 52 percent—from 88,686 to 134,647. Consequently, the proportion of S&E Ph.D.-holders who reported some research activity rose from 65 percent in 1979 to 76 percent in 1991. However, comparing data from fall 1991 with data gathered in the spring of 1989 (see "Changes in the Survey of Doctorate Recipients") suggests that this trend has leveled off.

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[20] Data on doctoral scientists and engineers are derived from the biennial Survey of Doctorate Recipients conducted for NSF by the National Research Council. (See "Changes in the Survey of Doctorate Recipients" for a discussion of the survey sample.) In this section, "academic institutions" refer to universities, 4- and 2-year colleges (the latter generally contribute little to R&D activity), and medical schools, as identified by the respondents, but exclude university-administered FFRDCs.

For 1991, no data are available on doctorate-holders employed in academic institutions who earned their degrees at non-U.S. institutions, or on those with non-S&E degrees working in science or engineering. Except for some limited data on graduate research assistants (discussed later in this section), no data are available on nondoctoral academic research personnel.

[21] Again, this discussion is limited to ***persons who received doctorates from U.S. institutions who are now working in science or engineering***. The number of academic researchers was determined based on responses to a question in the Survey of Doctorate Recipients on primary and secondary work activities. In 1991, respondents were asked: "From the activities listed below, select your primary and secondary work activities...in terms of time devoted during a typical week." Because many faculty members who devote a substantial amount of time to R&D often consider another activity (for example, teaching) to be their primary work activity, those survey respondents who selected academic R&D as either their primary *or* secondary work activity are included here. The inclusion of both sets of respondents yields an amount approximately twice that when only those reporting R&D as their primary activity are counted. These counts should not be considered full-time equivalents.

[22] This figure excludes those working in FFRDCs administered by universities or university consortia.

Changes in the Survey of Doctorate Recipients

Data on the academic employment and research activities of doctoral scientists and engineers are derived from the Survey of Doctorate Recipients (SDR), a sample survey sponsored jointly by the National Science Foundation and selected other federal agencies and conducted biennially by the National Research Council. In 1991, SDR underwent several design changes as part of a larger redesign and improvement of NSF's science and engineering personnel survey system. These changes affect the comparability of 1991 data with those of earlier years.

Through 1989, the SDR sample had included three major respondent segments: (1) persons with science or engineering Ph.D.s received from U.S. institutions, (2) holders of doctorate degrees in other fields working in science or engineering at the time of the survey, and (3) persons with science or engineering Ph.D.s earned at non-U.S. institutions. The 1991 sample retains only those respondents in category 1. Moreover, in an effort to improve response rates within budget constraints, sampling strata and overall sample size were reduced; several other changes were made as well, including a 31-month interval between the 1989 and 1991 surveys, rather than the usual 24 months.

Definitive statistical studies remain to be completed on the overall effects of these changes on the data and the range of interpretations permitted by them. Preliminary investigation suggests that the revised SDR survey system permits analysis of trends if the data used are limited to those respondents encompassed by category (1) above who are working in S&E fields in a given survey year.

Accordingly, the data reported here focus on that survey segment alone for all years. Status and trends in academic doctoral S&E employment and research activity are examined, in general, for two periods—1979-81 and 1989-91, the latest year for which these data are available. The 1979 and 1989 data are included to permit rough comparisons with data reported in previous *Science & Engineering Indicators* volumes, and to provide some idea of the extent of the SDR changes. Throughout this section, then, potentially interesting but small statistical differences should be treated cautiously. At least for the moment, their interpretation remains problematic.

The sharpest *gains* over the decade in research activity were experienced in the social sciences and mathematics. In 1979, 54 percent of the social scientists and 58 percent of mathematicians were involved in research; by 1991, these fractions had risen to 71 percent each. The highest *level* of research activity in 1991 (88 percent) was in the environmental sciences, followed by engineering and the life sciences with 82 percent each. (See appendix table 5-14.)

Academic Researchers by Field

The field composition of the academic research workforce underwent some changes in the past decade. These changes largely, but not entirely, reflected compositional shifts in the doctoral academic workforce as a whole.

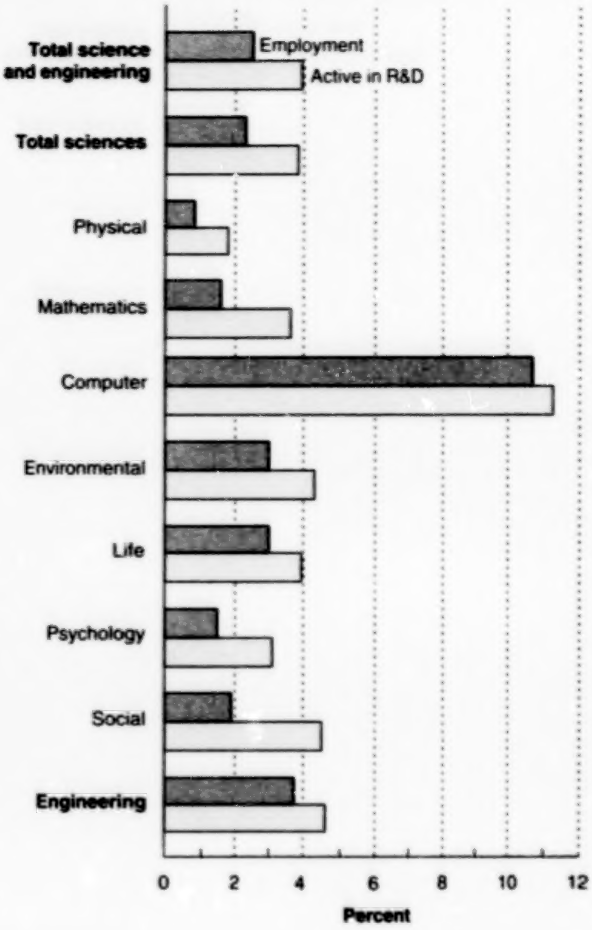
The number of researchers in the physical sciences grew more slowly than those in other fields—about 22 percent from 1979 to 1991, compared with 50 percent for all the sciences and 64 percent for engineering. (See figure 5-8.) Computer science researchers increased by 224 percent; employment growth in this field was also particularly strong. Life science researchers remained the largest group, maintaining their 38-percent share of the S&E total. Reflecting these shifts, the physical sciences declined from 15 percent to 12 percent of all investigators. Engineering increased its share of total S&E researchers from 11 to 12 percent, and the social sciences increased from 16 to 17 percent. The greatest relative shift was experienced by the computer sciences, whose share doubled to 3 percent. This increase was from a small base, however, and computer science employment still represents less than 3.5 percent of the academic doctoral S&E total.

The rate of increase in researchers from 1979 to 1991 substantially exceeded the increase in S&E employment in each major field. Consequently, the rate of participation in academic R&D increased in all major fields, rising from 75 to 82 percent for engineering, and from 64 to 75 percent for the sciences. (See appendix table 5-15.) But during the 1989-91 period, robust increases in the numbers of researchers were confined to mathematics, the computer sciences, and engineering; while slight declines were evident in the physical, life, and social sciences, and psychology. Overall employment in the latter two fields also fell.

Women in Academic R&D

The overall academic employment of female Ph.D.-holders in S&E more than doubled from 1979 to 1991, jumping from 16,650 to 35,600. (See text table 5-5.) Over the same period, the number of women active in R&D almost tripled, increasing from 9,761 to 25,207. (See appendix table 5-16.) Thus, by 1991, women constituted 20 percent of all academic doctoral scientists and engineers; in 1979, they had accounted for only 12 percent of this group. Reflecting this high rate of employment

Figure 5-8.
Average annual growth rates of employed academic doctoral scientists and engineers and those active in academic R&D: 1979-91



See appendix table 5-14. *Science & Engineering Indicators – 1993*

increase—albeit from a relatively small base—women represented almost one-fifth of all academic researchers, up from 11 percent a decade earlier.

The proportions of women researchers remained roughly in line with their increased rates of representation among the various S&E fields. For example, women accounted for 39 percent of those employed in psychology, and 36 percent of those active in psychology research; they accounted for 11 percent each of those employed in, and active in research in, the computer sciences. Their lowest rates of representation were in engineering, where women accounted for 3 percent of academic doctoral employment and 4 percent of academic doctoral researchers. (However, their representation in this field had increased from under 1 percent in 1979.)

Half of all women doctoral researchers were active in the life sciences. Relatively large proportions of women, compared to men, were also found in the social sciences and psychology. These three areas accounted for 85 percent of all women researchers in 1991, compared to 57 percent of all men. Women's field concentrations shifted somewhat over time. For example, from 1979 to 1991, the proportion of women researchers in the physical sciences and psychology declined by about 2 percentage points each, while a slightly larger proportion was found in the computer sciences and engineering.

Minorities in Academic R&D

The absolute number of minority researchers in academia remains low for all groups but Asians. However, since 1979, black, Hispanic, and Asian doctoral researchers in academia have increased substantially relative to their low numbers in 1979; increases for Native Americans seem to have been more modest.[23] (See text table 5-5.) Black S&E researchers increased from 707 in 1979 to 2,770 in 1991, Hispanic researchers from 931 to 3,038, and Asians from 3,630 to 13,105. Academic employment growth followed a similar pattern. (See appendix table 5-16.) The increases in these employment numbers are quite consistent with the number of S&E doctoral degrees awarded to minorities since the late 1970s, and suggest that a sizeable proportion of young minority doctorate-holders have found academic employment. (See chapter 2, "Doctoral Degrees in S&E.")

Each minority group made very strong gains, in relative terms, from 1979 to 1991. The increase in minority doctoral employment during this period exceeded 200 percent. Increases in the number of researchers exceeded 250 percent—290 percent for blacks, 260 percent for Asians, and 226 percent for Hispanics. (See text table 5-5.) Gains for specific fields varied, with the physical and life sciences, mathematics, engineering, and psychology broadly ranging around the S&E total, while the computer and environmental sciences well exceeded it (albeit from very low bases). (See appendix table 5-16.) As a result, minorities in 1991 comprised 13 percent of all S&E doctorate-holders employed in academe—up from just below 6 percent in 1979—and 14 percent of researchers —also up from 6 percent.

The field concentrations of minority researchers vary by race/ethnicity. In 1991, Asians disproportionately favored engineering and the computer sciences; lower proportions of Asians entered the environmental and social sciences and psychology. In this same relative sense, Hispanics tended toward mathematics, engineering, and the social sciences, and away from psychology and the life sciences. Blacks in 1991 tended away from physical and environmental sciences, mathematics, and engineering, and toward psychology and the social sciences. (The numbers for Native Americans in the sample survey are too small to allow for meaningful breakdowns.)

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[23] Note that these numbers derive from a sample survey and should be taken not as precise enumerations, but as rough indicators of the actual population. This caveat is especially true for data on Native Americans because of the very low number of respondents.

Text table 5-5.
Academic employment and R&D involvement of women and minority doctoral scientists and engineers

Field	Total employment 1979	Total employment 1991	Change from 1979-91	Active in R&D 1979	Active in R&D 1991	Change from 1979-91
	Number		Percent	Number		Percent
Women						
Total sciences	16,555	34,934	112	9,687	24,588	155
Engineering	94	665	615	74	619	736
Minorities						
Total sciences						
White	115,730	138,474	20	74,063	102,766	39
Asian	3,653	11,868	225	2,724	10,266	277
Black	1,234	3,996	224	700	2,585	269
Hispanic	1,180	3,335	183	847	2,613	209
Native American	235	340	45	168	239	42
Engineering						
White	11,519	15,019	30	8,532	12,116	42
Asian	951	3,264	243	906	2,839	213
Black	*	227	NA	*	185	NA
Hispanic	273	503	84	84	425	406
Native American	*	*	NA	*	*	NA

*Omitted because of small sample size.

See appendix table 5-16.

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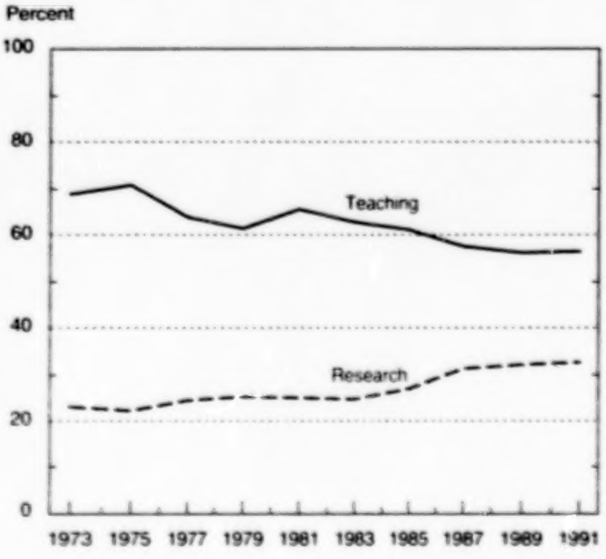
Teaching and Research as Primary Work Responsibility

A number of reports in recent years have expressed concern that university faculty are unduly focusing on research at the expense of teaching.[24] Data from the Survey of Doctorate Recipients cannot directly address this issue, but can illuminate certain aspects of it. Academic doctoral S&E faculty members[25] were asked what they considered to be their primary work responsibility. (See appendix table 5-15.) For all S&E fields, the numbers reporting their primary work responsibility as either teaching or research[26] have increased since 1979. However, the number naming research as their primary activity increased much more rapidly (rising roughly 60 percent between 1979 and 1991) than did the number of those naming teaching (which rose about 15 percent).

Figure 5-9 displays the resulting composition shift. The more rapid increase for research over the 1979-91 period holds for every major field—even those that experienced a slowdown or decline in employment in 1991. But in most S&E fields, the number of faculty reporting primary teaching responsibility has kept pace with full-time enrollment and degrees awarded. (See appendix table 5-15.)

Those with primary research responsibility in S&E accounted for more than 60 percent of the increase in

Figure 5-9.
Proportion of academic doctoral science and engineering faculty with primary responsibility for research or teaching



See appendix table 5-15.

Science & Engineering Indicators – 1993

faculty from 1979 to 1991. For the computer sciences, engineering, psychology, and the social sciences, their share ranged from 35 to 50 percent; and for the life sciences, 85 percent. The physical sciences showed no employment growth over the period, and no growth in the number of faculty with primary responsibility for teaching. This field did, however, experience an increase in the number reporting primary research responsibility, i.e., shifting toward research from other endeavors.

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[24] See chapter 2, "Undergraduate Instruction by Type of Faculty," for a discussion of this issue.

[25] Faculty is defined here as a respondent reporting employment in S&E as either a professor, associate professor, assistant professor, instructor, or lecturer.

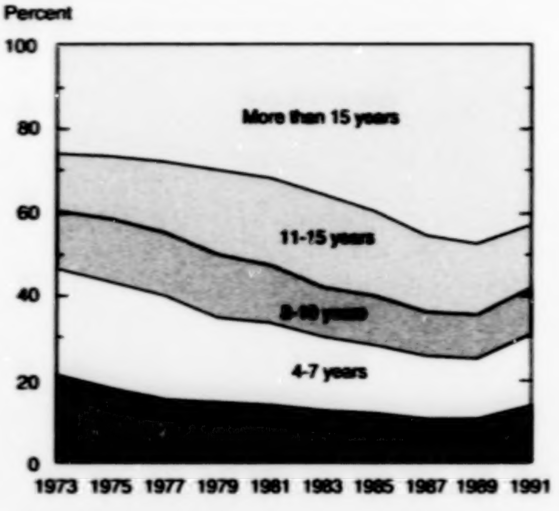
[26] Respondents listing teaching as their primary work responsibility often list research as their secondary one, and vice versa. Particularly in advanced graduate training, the two are closely intertwined. The focus here on primary work responsibility is not meant to imply that people are *either* researchers or teachers.

Changing Age Structure of Academic Researchers

A nearly two-decade-long trend toward an aging academic research workforce is starting to reverse. (See figure 5-10.) The average age of academic researchers had increased steadily since 1973, the first year for which such a series can be constructed. This trend resulted from the hiring of many young scientists and engineers during the rapid expansion of U.S. higher education during the 1960s, followed by a hiring slowdown. The median age of academic *researchers* rose from 38.9 years in 1973 to 44.4 years in 1989, but fell to 43.6 years in 1991. The median age of *faculty* active in research was consistently higher but followed the same general pattern: 39.4 years in 1973, 45.4 in 1989, and 44.5 years in 1991.

Put another way, in 1973 only 25 percent of academic researchers had earned their Ph.D. degrees more than 15 years earlier; this fraction had risen to 47 percent by 1989, but declined to 43 percent by 1991. Conversely, "young" researchers (those who had earned their Ph.D. degrees within 7 years of the survey date) comprised 47 percent of the total in 1973, only 25 percent in 1989, but 31 percent in 1991. (See figure 5-10.) Among the major fields, the life sciences and computer science have maintained relatively younger researcher pools, while mathematics has "aged" the most. (See text table 5-6 and appendix table 5-17.)

Figure 5-10.
Distribution of academic science and engineering researchers by years since Ph.D.



See appendix table 5-17

Science and Engineering Indicators – 1993

Research Participation

Throughout the 1980s, a growing proportion of academic scientists and engineers in all age groups reported that they participated in research. For example, while 74.2 percent of those within 3 years of receiving their doctorates reported such involvement in 1979, by 1989,

Text table 5-6.
Academic doctoral researchers by number of years since doctorate award and field

Field	Years since degree	1973	1979	1981	1989	1991
		Percentage in age group				
Total science and engineering	1–7	46.8	34.6	33.6	25.4	30.9
	>15	25.8	29.8	31.9	47.0	42.6
Physical sciences	1–7	43.5	26.1	27.3	21.6	27.7
	>15	26.5	35.9	39.3	59.0	53.3
Mathematics	1–7	55.9	28.0	28.2	18.8	28.8
	>15	18.1	25.9	31.3	56.9	43.6
Computer sciences	1–7	47.5	40.3	43.3	26.8	41.0
	>15	21.9	21.0	21.3	39.6	35.1
Environmental sciences	1–7	46.0	33.6	35.0	26.1	28.4
	>15	24.7	29.6	30.1	44.9	42.0
Life sciences	1–7	42.6	36.9	35.9	29.2	32.5
	>15	31.6	30.7	31.1	42.0	38.4
Psychology	1–7	51.3	44.5	39.2	26.3	31.3
	>15	21.9	25.2	26.2	44.1	43.1
Social sciences	1–7	51.7	41.5	37.5	23.7	29.4
	>15	23.4	23.3	26.8	44.0	41.9
Engineering	1–7	47.5	24.7	22.7	21.3	30.2
	>15	19.7	34.6	40.5	55.2	46.9

See appendix table 5–17.

Science & Engineering Indicators – 1993

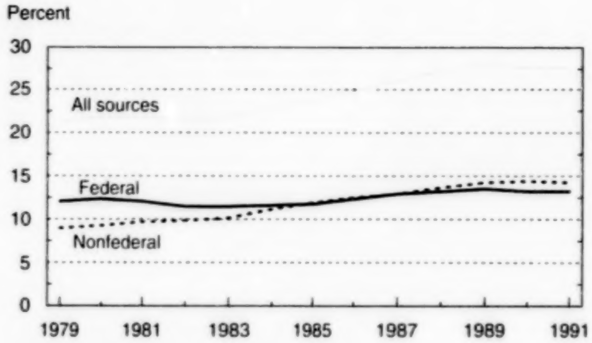
Participation of Graduate Students in Academic R&D

In 1989, 28 percent of all full-time S&E graduate students (79,595) were supported by research assistantships. While the total *number* of full-time S&E graduate students whose primary source of support was a research assistantship continued to rise to a reported 84,901 in 1991, the upward trend in the *proportion* of students so supported ended in 1989—concluding a 7-year trend. For both 1990 and 1991, 27.5 percent of full-time graduate S&E students received such support.

Since 1972, the Federal Government has provided research assistantships to an increasing number of full-time S&E graduate students (40,609 or 13 percent in 1991), but again the *proportion* so supported has remained quite steady, fluctuating around 12 to 14 percent. Similarly, although nonfederal research assistantships were awarded to an increasing proportion of students (from 9 percent in 1979 to 14 percent by 1989), that proportion also stopped growing in 1989. The increase in ***numbers*** of nonfederal research assistantship awards continued, but the ***proportion*** remained at 14 percent in 1991. (See figure 5-11 and appendix table 5-18.)

Certain S&E fields have higher proportions of graduate students supported by research assistantships. The physical and environmental sciences and engineering continue to have the highest proportions of graduate students supported by research assistantships (between 38 and 42 percent), followed by the life sciences (31 percent). In contrast, only 16 percent of mathematics and computer science students had such support; this support was evenly split between federal and nonfederal sources. Thirteen percent each of the students in psychology and the social sciences were supported by research assistantships provided primarily by the nonfederal sector. (See appendix table 5-18; for more information on graduate student support, see chapter 2.)

Figure 5-11.
Proportion of full-time graduate students in science and engineering with research assistantships, by source



See appendix table 5-18. *Science & Engineering Indicators – 1993*

this proportion had risen to 84.6 percent. Similarly, of those more than 15 years beyond receipt of their doctorates, 60 percent reported research involvement in 1979 compared to 71 percent in 1989. By 1991, this trend toward ever-greater proportions reporting research activities appears to have leveled off for most fields and age groups—and even to have reversed in some cases. The attenuation in research intensity is further demonstrated by a flattening out of the proportion of graduate students supported by research assistantships. (See "Participation of Graduate Students in Academic R&D" and appendix table 5-18.)

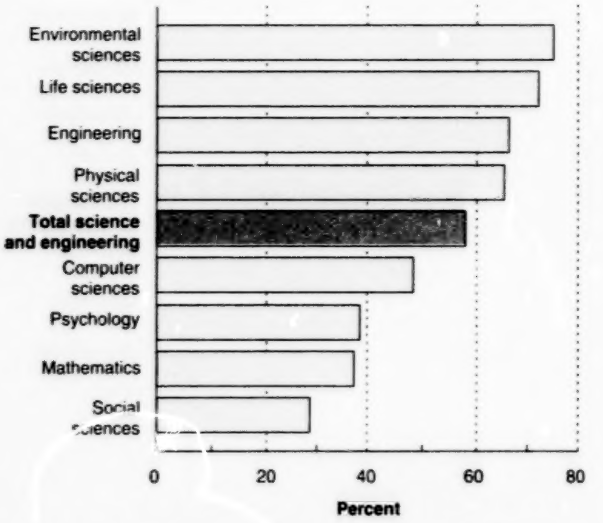
Federal Support of Academic S&E Researchers

Although the Federal Government's *share* of academic R&D funding declined from 67 percent in 1979 to about 60 percent in 1989, a rising proportion of all academic researchers reported receiving at least some federal support for their work. These increases were experienced by all age groups and all major fields (except the social sciences, which maintained their 1979 level of federal support). By 1991, the federal share dropped still further to 58 percent, and the rate of increase in federal funding slowed. The decade-long trend of increasing proportions of academic researchers with federal support stopped, although remaining generally higher than a decade ago for most fields and age groups. (See appendix table 5-19.)

Overall, the 1991 decline in the federally supported proportion occurred among younger doctorate-holders, especially those in the physical, life, and social sciences, and in psychology. Mathematics (which traditionally has had a low proportion of federally supported researchers), the environmental sciences, engineering, and—to a lesser degree—the computer sciences are exceptions to the general trend.

Notable field differences exist in the proportion of researchers with federal support. Above the mean of 58 percent for all S&E are the environmental, life, and physical sciences, and engineering, which ranged from 65 to 75 percent. The computer sciences, mathematics, psychology, and the social sciences are below the mean, ranging from 29 to 48 percent. (See figure 5-12.) For related information on federal support of academic researchers, see "Multiple Versus Single Agency Support" and "Participation of Graduate Students in Academic R&D."

Figure 5-12.
Academic doctoral researchers reporting federal support, by field: 1991



See appendix table 5-19. *Science & Engineering Indicators – 1993*

Outputs of Academic R&D: Scientific Publications and Patents

A principal output of university research is new knowledge—an output that is difficult to conceptualize and measure. Nonetheless, several useful indicators of the outputs of academic R&D do exist. One such indicator is publication counts—that is, the number of scientific and technical journal articles. Another useful indicator is the number of patents awarded to U.S. universities.[27] Both of these indicators are discussed below. For a discussion of another main output of academic institutions—educated students—to which research contributes, see chapter 2, "Higher Education in Science and Engineering."

World Literature in Key Journals[28]

U.S. Share. Scientists and engineers in the United States continue to produce a substantial share of the world's new S&E knowledge. In 1991, U.S. authors published over 142,000 articles in the natural sciences and engineering in a set of 3,500-plus journals; over 70 percent of these publications came from the academic sector. The total number of U.S. articles accounted for 35 percent of the world's output in these fields. This proportion represents a modest decline of about 1 percentage point since 1981, continuing a gradual decline in world share—albeit at an attenuated rate—that began during the 1970s. (See appendix table 5-21.)

This trend has not affected all fields equally. (See figure 5-14 and appendix table 5-21.) In chemistry, the United States had, by 1991, regained the world share it held in the early 1970s (23 percent); in mathematics, the U.S. national *share* increased, even though its actual *number* of articles declined, largely because of a still greater decline in the number of articles in this field worldwide. The reverse held true for clinical medicine. In this field, world publications increased more rapidly than did the number of U.S. articles, leading to a declining U.S. share. In engineering and technology, both U.S. articles and U.S. world share declined strongly during the 1980s, losing almost 5 percentage points. Gains and losses for some specific specialties (some of which have relatively few publications) are even more pronounced. (See appendix table 5-22.)

Nevertheless, the U.S. share of world publications far exceeds that of any other single country. (See appendix table 5-23.) In 1991, the United States produced

- 23 percent of the world literature in chemistry,
- 30 percent of physics publications, and
- between 36 and 42 percent of the literature in the other major fields.

Foreign Country Shares. Scientists and engineers in the United States, the European Community, and Japan produce about two-thirds of the world's influential S&E literature. As noted earlier, the United States accounts for the largest share—35 percent of the total in 1991. Authors in all European Community countries together accounted for another 27 percent, with the United Kingdom, Germany, and France contributing 7.5, 6.8, and 4.8 percent, respectively. Japan provided 8.5 percent of the world's total scientific and technical literature in 1991; the former Soviet Union contributed about 7 percent. Canada accounted for the next largest share of the literature at 4.2 percent. Sweden, the Netherlands, Australia, and India contributed about 2 percent each, as did the Eastern and Central European countries outside the former Soviet Union (down from 3 percent a decade earlier). About 1 percent each was contributed by Switzerland, China, and the Asian newly industrialized countries group. The latter two entities increased from 0.3 and 0.2 percent, respectively, in 1981.[29] (See appendix table 5-23.)

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[27] See chapter 6, "Patented Inventions," for a discussion of the limitations of patents data.

[28] These publication count data are based on a set of more than 3,500 influential technical journals tracked by the Institute of Scientific Information in its Science Citation Index. (The social sciences and social aspects of psychology are not captured in this data set.) It is unclear what share of the total world S&E publications is represented by these journals. However, this set is generally considered to be representative of scientific and technical journals of the Western industrialized nations, though less so of other countries. Publication counts before 1981 are based on a smaller set of journals—around 2,100—but many of the relative trends (i.e., field or country shares) appear to hold true across the two data sets.

[29] Note that for developing and Eastern and Central European countries, absolute levels of publications are less important than the trends in their publications behavior—i.e., declines for the former during the 1980s, and strong increases (from a small base) for some of the latter.

Multiple Versus Single Agency Support*

Between 1979/81 and 1989/91, there were increases in both the number and percentage of S&E doctorate recipients employed at U.S. universities and colleges who reported that they received support from the Federal Government. These increases occurred in all S&E fields. While the majority (80 percent in 1979/81) of academic S&E doctorate-holders reported receiving support from only a single federal agency, a growing proportion—28 percent in 1989/91, compared to 20 percent in 1979/81—reported support from a number of agencies. (See figure 5-13 and appendix table 5-20.)

The extent of reliance on single or multiple agency support varied considerably by S&E field both in the earlier and later periods. However, all S&E fields reported an increase in the percentage of those federally supported academic doctorate recipients supported by more than one agency: The largest increase occurred in the computer sciences, which rose from about 21 to 39 percent.

Mathematical scientists, life scientists, social scientists, and psychologists report the highest percentage (about 80 percent in 1989/91) of reliance on a single agency for their support. The lowest percentage was reported by federally supported academic doctoral environmental scientists (50 percent). The remaining fields—physical sciences, computer sciences, and engineering—fall somewhere in between these proportions.

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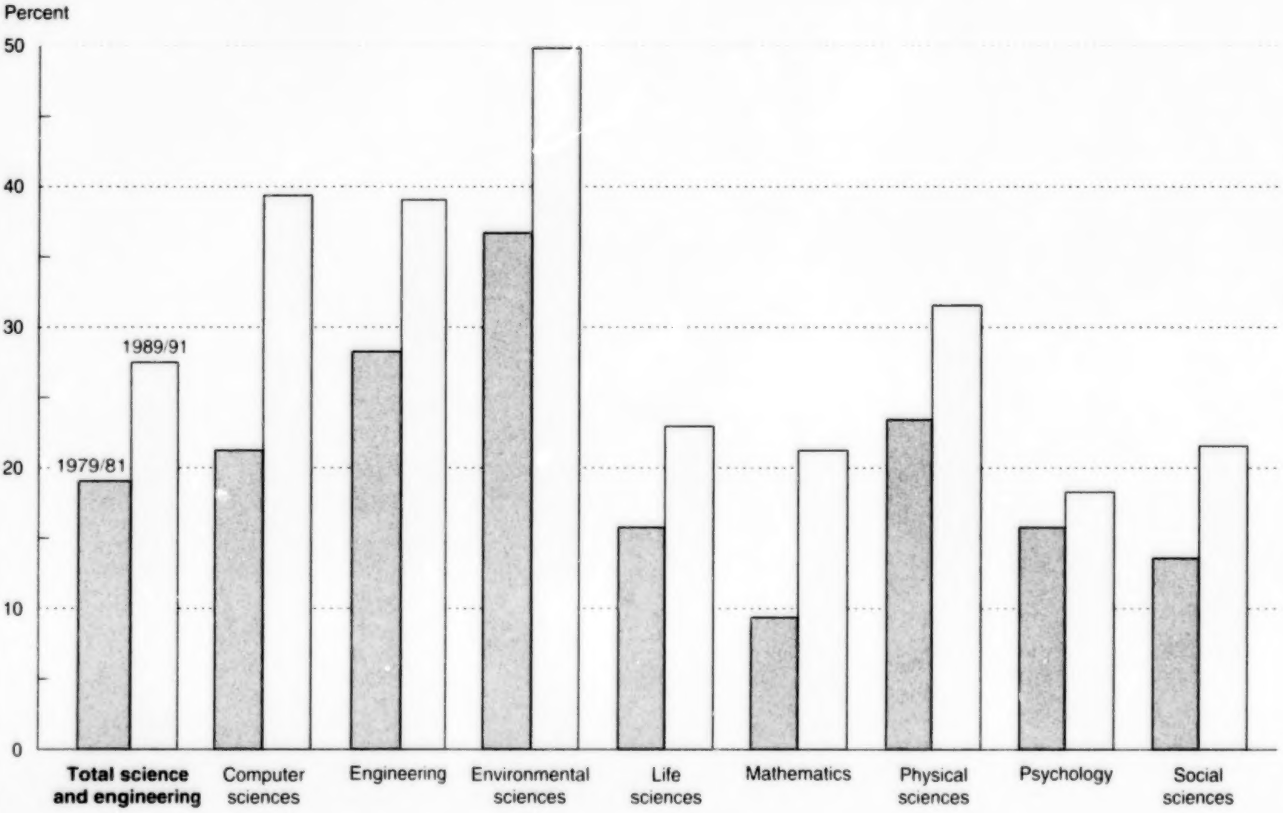
*The data underlying this discussion are derived from a question in the biennial Survey of Doctorate Recipients. Respondents are asked whether they have received federal support and, if so, from which agencies.

Figure 5-13.
Proportion of federally supported academic doctorate-holders reporting multiple agency support, by field

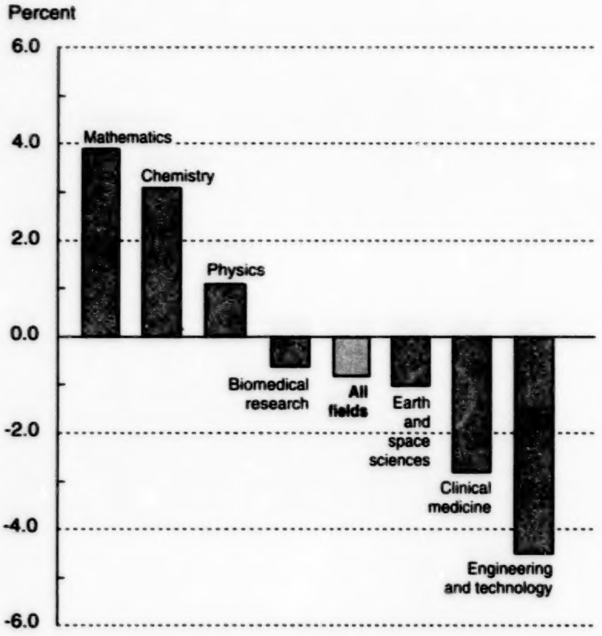


NOTE: Each bar represents data for two years — either 1979 and 1981 or 1989 and 1991.

See appendix table 5-20.

Science & Engineering Indicators – 1993

Figure 5-14.
Percentage change in U.S. share of world scientific and technical articles: 1981-91



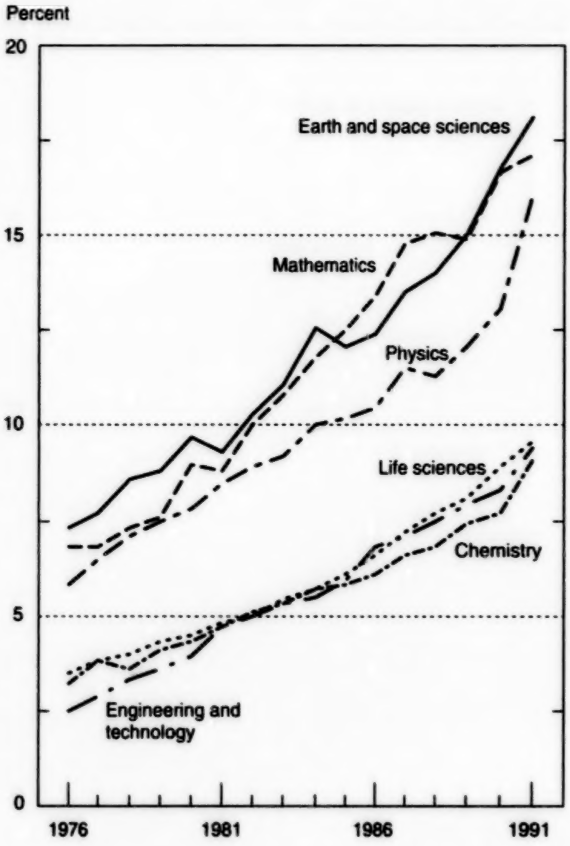
NOTE: There was no change in share for biology articles.
See appendix table 5-21. *Science & Engineering Indicators – 1993*

International Coauthorship. A strong trend is evident toward international coauthorship.[30] (See appendix table 5-24.) In 1991, 11 percent of the world's scientific and technical articles were internationally coauthored, double the proportion of a decade earlier. This rise in coauthorship has affected all major fields. The earth and space sciences, mathematics, and physics have the largest percentages of coauthored articles. (See figure 5-15.)

U.S. Publication Patterns. Over 60 percent of U.S. publications in 1991 were in the life sciences, particularly in clinical medicine and biomedical research, which together accounted for more than half of U.S. publications. (See figure 5-16.) This proportion for the life sciences as a whole has been roughly stable over the past decade. (See "U.S. and World Publications in Biology and Biomedical Research" and appendix table 5-21.)

The sectoral origins of U.S. science and engineering articles remained quite stable during the 1980s with a marginal increase in the academic share and offsetting declines in those of FFRDCs and the Federal Government. About 70 percent of U.S. articles are published by academic researchers. Industry, the Federal Government, and nonprofit organizations contribute 7 to 9 percent each, while about 3 percent are written by FFRDC researchers. (See appendix table 5-25.)

Figure 5-15.
Internationally coauthored articles as a percentage of all articles



NOTE: Life science publications are articles in clinical medicine, biomedical research, and biology.
See appendix table 5-24. *Science & Engineering Indicators – 1993*

In all fields except mathematics, academic authors supplied between 60 and 77 percent of U.S. articles. In mathematics, they account for 92 percent of the articles.[31] Major field concentrations for industry are found in engineering and technology (24 percent of total) and in chemistry and physics (17 percent each); major concentrations for the Federal Government are in earth and space sciences (15 percent) and biology (14 percent); for nonprofit organizations in clinical medicine (13 percent); and for FFRDCs in physics (13 percent).

Industry-University Coauthorship. An increasing share of the articles published by industry-based authors is coauthored with academic scientists or engineers. In 1991, 35 percent of all industry articles had such coauthorship—up from 22 percent a decade earlier.[32] The trend toward industry-university coauthorship affected all

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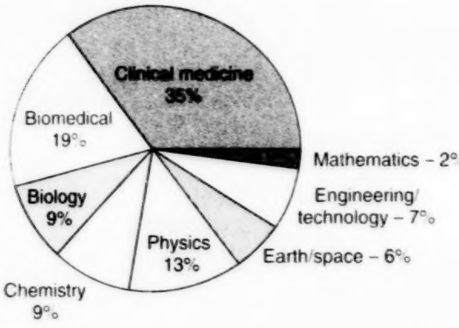
[30] In international coauthorship situations, at least one author's institutional affiliation is in a country different from that of the other(s).

[31] Coincidentally, this field has a relatively small share of researchers supported by federal funds.

[32] This increase in university-industry cooperation is also reflected in funding patterns (see chapter 4 and "Financial Resources for Academic R&D," earlier in this chapter).

Figure 5-16.
Distribution of U.S. publications by field: 1991



See appendix table 5-21. *Science & Engineering Indicators – 1993*

major fields, albeit to varying degrees. Industry articles in chemistry and engineering and technology were least likely to have a university-based coauthor (24 and 26 percent, respectively); those in the life science fields and mathematics were the most likely (40 to 49 percent). (See appendix table 5-26.)

Patents Awarded to U.S. Universities[23]

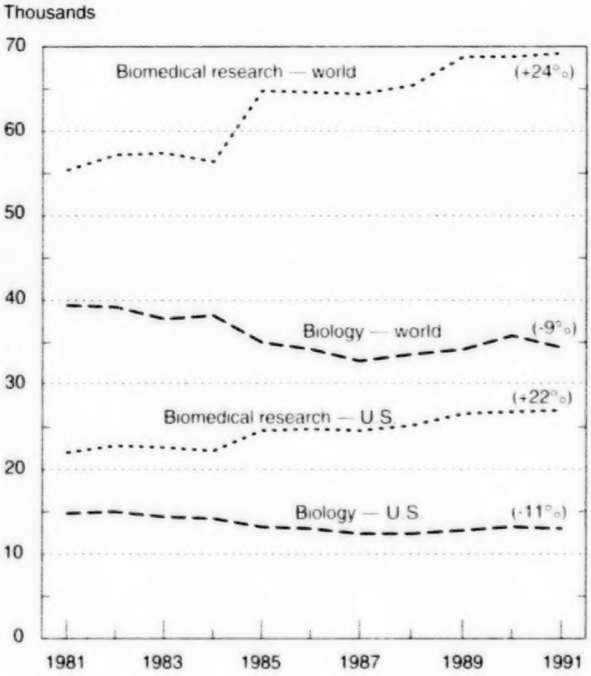
The recent marked increase in university patenting may be seen as an indicator of the potential role academic R&D can play in the development of technology and new products. The number of patents awarded to U.S. universities, which had increased sharply during the 1980s, continued to rise through 1991. (See appendix table 5-27.) In 1991, 1,324 patents were awarded to academic institutions, compared to a previous high of 1,218 in 1989 and only 437 a decade earlier. The increase during the eighties was partly due to a 1980 change in U.S. patent law that allows academic institutions and small businesses to retain title to inventions resulting from federally supported R&D. In 1991, U.S. universities received 1.4 percent of all U.S. patents, up from 1.0 percent in 1980.

University patenting increased particularly rapidly during the second half of the 1980s and early 1990s. In fact, 24 percent of all patents issued to U.S. academic institutions since 1969 were awarded in 1990-91. Prominent among higher volume patent classes in the late 1980s and early 1990s were those involving health or biomedical applications; superconductor technology; chemistry; optics; and computing, electronics, and information processing. (See appendix table 5-28.)

U.S. and World Publications in Biology and Biomedical Research

There has been a shift in the relative field distributions between articles in biomedical research and those in biology, both in the United States and worldwide. Between 1981 and 1991, the number of biomedical articles published worldwide has increased by 24 percent, and by 22 percent for U.S. authored articles. In contrast, articles reporting biology research results fell by 9 percent worldwide, and by 11 percent for the United States. (See figure 5-17.)

Figure 5-17.
Shifts in U.S. and world articles in biomedical research and biology



See appendix table 5-21. *Science & Engineering Indicators – 1993*

The 100 largest research universities account for a large share of all academic patents—about 85 percent in the 1987-91 period. (See appendix table 5-27.) This proportion was an increase over the 1969-75 period, when these institutions received 75 percent of the patents. Between 1969 and 1975, only 64 of the top 100 received patents; in the 1987-91 period, this number rose to 88.

However, a composition shift has taken place in academic patenting. The very largest (top 20 by research volume) and very smallest institutions (i.e., those ranked below 100) are being awarded a smaller share of all academic patents than in the past, while institutions ranked 21 to 100 have growing shares. (See figure 5-18.) This trend reflects relatively stronger growth in patenting activity among the middle-tier institutions.

Patents represent a potential source of funds for academic institutions. For a brief discussion of this topic, see "Income From Patenting and Licensing Arrangements."

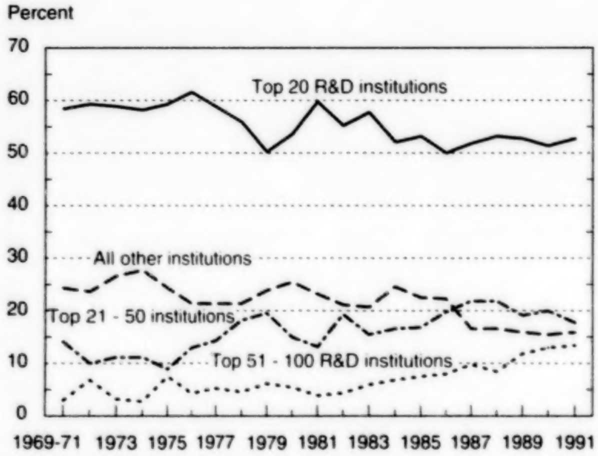
Income From Patenting and License Arrangements

Although no nationally representative data are available on the revenues universities derive from patents and licensing arrangements, a recent General Accounting Office study (GAO 1992) reported on the patent and licensing activities of 35 major research universities:

"During fiscal years 1989 and 1990, the 35 universities in our study (1) granted 197 exclusive licenses and 339 nonexclusive licenses and (2) earned $29.3 million from exclusive licenses and $52.7 million from nonexclusive licenses. Typical licensees given exclusive rights to commercialize the results of federally funded research were small U.S. businesses; and most exclusive licensees were pharmaceutical, biotechnology, or other medical companies.

"Most of the surveyed universities substantially expanded their programs to transfer technology to businesses during the 1980s. Twelve universities formed an office to license technology, while many others expanded and/or reorganized their technology licensing activities. For example, Harvard University, which granted its first license in December 1980, granted 39 licenses in fiscal year 1990."

Figure 5-18.
Proportion of patents granted to academic institutions, by volume of institutions' research activity



NOTE: Research volume is based on 1988 R&D expenditures.

See appendix table 5-27. *Science & Engineering Indicators – 1993*

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Chapter 6
Technology Development and Competitiveness

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Highlights

INTERNATIONAL ECONOMIC COMPARISONS

- **The United States economy continues to rank as the world's largest and Americans continue to enjoy one of the world's higher standards of living—but other parts of the world are quickly catching up.** Japan's economy was less than 10 percent of the U.S. economy in 1960 and trailed most of the major European economies. By 1991, it had grown to be the world's second largest economy with a gross domestic product (GDP) twice that of former West Germany and equal to nearly 42 percent of U.S. GDP. Several Asian newly industrialized economies show similar patterns of growth starting in the late 1970s.

- **Comparisons of general levels of labor productivity, measured by GDP per employed person, again show other parts of the world quickly closing in on the U.S. lead position. For the past 40 years, labor productivity growth in the United States consistently fell below almost all other countries.** In 1960, U.S. GDP per employed person was twice that calculated for most European nations and four times that calculated for Japan. By 1991, the gap closed significantly with labor productivity rates in many European nations and in Japan rising to 70 to 90 percent of the U.S. rate.

THE GLOBAL MARKETS FOR U.S. TECHNOLOGY

- **The United States continues to be the leading producer of high-tech products, responsible for over one-third of total OECD-country production.** However, its leadership is being challenged by Japan, which increased its share of OECD production of high-tech products during the 1980s and early nineties.

- **The market competitiveness of U.S. high-tech industries varies by industry.** Of the six industries that form the high-tech group, three U.S. industries—those producing scientific instruments, drugs and medicines, and aircraft—gained global market share during the 1980s and maintained that market share into the early 1990s.

- **Despite a domestic focus, U.S. producers are important suppliers of high-tech products in overseas markets.** U.S. producers led all other countries in high-tech exports in 1981 and 1982. Japan's exports of high-tech products surpassed the United States and Germany in 1983 and continued to lead by varying margins through 1992.

- **Of the six industries that form the high-tech group, in 1992 Japan led the world in exports of communication equipment, computer equipment, electrical machinery, and in exports of scientific instruments.** The United States was the leading exporter in only one high-tech industry—aircraft.

- **By the mid-1980s, U.S. high-tech exports failed to keep pace with U.S. imports of high-tech products producing persistent annual trade deficits through 1992.** Trade in computer and office equipment shows the greatest deficit of all the high-tech areas. Nevertheless, three of the six high-tech areas continue to show trade surpluses: aircraft, pharmaceuticals, and scientific instruments.

- **The United States is the world's largest national market for high-tech products, and U.S. demand for high-tech products was increasingly met by foreign suppliers during the 1980s and into the early 1990s.** Import penetration of U.S. high-tech markets was deepest in the computer industry. Foreign suppliers also gained market share in the other industrialized countries, including Japan. Still, as of 1992, Japan continues to be the most self-reliant among the major industrialized countries.

INDUSTRIAL R&D

- **Despite a two-decade decline in its international share of all industrial R&D, the United States remains the leading performer of industrial R&D by a wide margin.** In 1990, it surpassed the combined R&D performed in the industrial sector of the 12-nation European Community and was twice that performed in Japan.

- **R&D is highly concentrated in a few industries. Eight industries accounting for over 80 percent of all industrial R&D performed in this country.** The aircraft and communications equipment industries have consistently been the largest performers of R&D in the United States. The U.S. computer and office equipment industry has taken over third place from the U.S. motor vehicle industry. In 1990, these three industries together accounted for over 50 percent of all industrial R&D performed in the United States.

- **Since 1973, R&D performance in Japanese manufacturing industries grew at a higher annual rate than in the United States, and, since 1980, faster than all other industrialized countries.** Industrial R&D in Japan is less concentrated than in the United States, with its top three R&D performing industries—communications equipment, motor vehicles, and electrical machinery—accounting for around 40 percent of national total. Rapid R&D growth in the Japanese computer and office equipment industry during the 1970s and 1980s moved that industry among that country's top five industry performers by 1984.

- **German industrial R&D appears to be somewhat less concentrated than in the United States, but more so than in Japan with the same five industries leading the country in r&d performed.** The five industries included in the top five R&D performers in Germany mirror German commercial prominence as a supplier of world-class machinery and motor vehicles.

PATENTED INVENTIONS

- **The number of u.s. patents granted to Americans has been increasing since 1983.** Patent activity by foreign inventors in the United States generally followed the U.S. trend, although the number of foreign-origin patents granted declined somewhat slower during 1976-83 and increased somewhat faster after 1983.
- **Foreign patenting in the United States is highly concentrated by country of origin.** Inventors from the European Community and Japan account for 80 percent of all foreign-origin U.S. patents. Newly industrialized economies, notably Taiwan and South Korea, dramatically increased their patent activity in the United States during the last half of the 1980s.
- **Recent patent emphases by foreign inventors in the United States show widespread international focus on several commercially important technologies.** Japanese inventors are earning patents in information technology, as are German inventors, who—along with French and British inventors—are also showing high activity in biotechnology-related patent fields. Inventors from Taiwan and South Korea are earning an increasing number of U.S. patents in technology fields related to communications and electronic componentry.
- **Americans successfully patent their inventions around the world.** In 1990, countries in which U.S. inventors received more patents than other foreign inventors included Japan, the United Kingdom, Canada, Mexico, Brazil, and India.
- **International patenting in three important technologies—robot technology, genetic engineering, and optical fibers—underscores the inventive activity by the United States, Japan, and Europe in these diverse technologies.** Based on an examination of national patenting activity in 33 countries during 1980-90, Japan and the United States lead in overall technological activity in these areas.
- **U.S. position in these technologies improved over the decade as did the technological significance of its inventions corrected for level of activity.** However, Japan's contribution to the most significant work in these technologies is lower than would be expected based on its high level of activity. Great Britain and France appear to produce significant new technologies at a higher rate than would be expected based on their somewhat lower level of international patent activity.

SMALL HIGH-TECH BUSINESS

- **Since the late 1980s, there has been a sharp decline in new high-tech company formations.** This decline follows a period of rapid formation of such companies during the second half of the 1970s and into the early 1980s.
- **Software development companies exhibited strong relative share growth in the early 1990s.** Other fields experiencing such growth were the biotechnology, advanced materials, and photonics and optics fields.
- **Fewer than 7 percent of U.S. high-tech companies are foreign owned—down from 11 percent just 2 years ago.** The United Kingdom is the largest foreign holder of U.S. high-tech companies, followed by Japan and Germany.

NEW HIGH-TECH COMPETITORS

- **Several Asian countries seem headed toward future prominence in technology development and a greater presence in global high-tech product markets,** when a model of leading indicators is applied. Taiwan and South Korea seem best positioned to enhance their stature in technology-related fields and their competitiveness in high-tech markets. Malaysia and Singapore could be the next Asian "tigers," although their technological base seems narrower than

Introduction

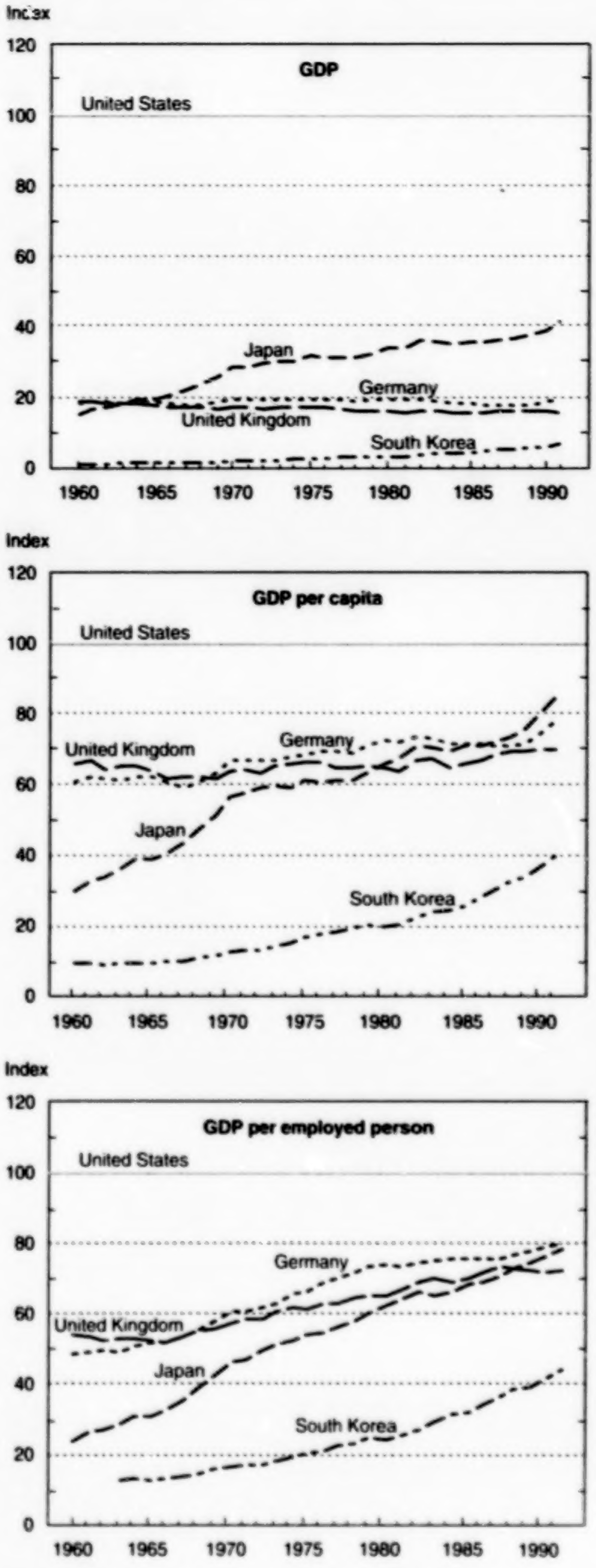
Chapter Background

Perhaps not since the launch of Sputnik has the national spotlight been turned so directly on the U.S. science and technology (S&T) enterprise. In these post Cold War times, policy interests have become more narrowly focused on the economy and on finding ways to improve U.S. economic competitiveness. U.S. science and engineering, and the technologies that emerge from related research and development (R&D) activities, are widely recognized for their contributions to the Nation's economic growth. Accordingly, they are an important component of the national effort to improve U.S. competitiveness.

Bolstered by both private and public investments in R&D, American technological innovation spawned new industries, revolutionized the way manufacturing was done, and raised expectations as to how products should perform. U.S. leadership in the world economy was made possible by these many technological breakthroughs—breakthroughs made possible by the U.S. science and engineering enterprise during the 20th century.

Today, the United States is facing a challenging global economy that becomes more dynamic and more intensely competitive with each passing decade. Previously, the lower paid, labor-intensive U.S. industries fell victim to global competition; by the 1980s, however, U.S. high-tech industries also found intense foreign competition—especially from Japan and Europe—in markets they once dominated. And in the 1990s, competition opened on yet another front as several of the newly industrialized economies (NIEs) posed new challenges for U.S. producers.

Figure 6-1.
International economic comparisons



NOTES: Index: United States = 100. Country GDPs were calculated using 1985 purchasing power parities. German data are for the former West Germany only.

See appendix tables 6-1, 6-2, and 6-3.

Science & Engineering Indicators – 1993

A nation's competitiveness is often evaluated on its ability to produce goods that find demand in international markets while simultaneously maintaining, if not improving, the standard of living of its citizens.[1] Although the U.S. economy continues to rank as the world's largest, and Americans continue to enjoy one of the world's higher standards of living, many other parts of the world are closing the gap. (See figure 6-1 and appendix tables 6-1, 6-2, and 6-3.) The Clinton Administration makes the connection between investments in technology and a growing economy. Clinton and Gore (1993) envision

> "...more high-skill, high-wage jobs for American workers; a cleaner environment where energy efficiency increases profits and reduces pollution; a stronger, more competitive private sector able to maintain U.S. leadership in critical world markets; an educational system where every student is challenged; and an inspired scientific and technological research community focused on ensuring not just our national security but our very quality of life."

The new administration sees the U.S. science and technology enterprise as a resource that needs to be more committed to American industry in order that a new U.S. paradigm for economic growth might be defined that can enhance U.S. industrial competitiveness and sustain the U.S. standard of living. This chapter brings together information on S&T activities that are key elements of this new paradigm: technology development and the competitiveness of U.S. industries that rely on and commercialize new technologies.

Chapter Organization

U.S. technology development and competitiveness span activities and issues that cannot be fully explored in the present context. Instead, this chapter presents several sets of indicators that provide measures of national activity and international standing in these areas.

The chapter begins with a review of market competitiveness of manufactured products that incorporate high levels of R&D, produced by what are often referred to as high-technology industries.[2] The importance of high-tech industries is linked to their high R&D spending and performance which produce innovations that "spill over" into other economic sectors and because they help to train new scientists, engineers, and other technical personnel (see Tyson 1992). The market competitiveness of a nation's technological advances, as embodied in new products and processes associated with these industries, can also serve as an indicator of the effectiveness of that country's S&T enterprise. The marketplace provides a commercial-based evaluation of a country's use of science and technology.

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[1] For further discussion of international competitiveness, see Competitiveness Policy Council (1993) and OTA (1991).

U.S. high-tech industry competitiveness is assessed through an examination of market share trends in both foreign and domestic markets. New data on royalties, fees, and technology agreements are used to gauge U.S. competitiveness in terms of intangible (intellectual) property and technological know-how.

The chapter then explores several leading indicators of technology development (1) via an examination of changing emphases in industrial R&D among the major industrialized countries and (2) through an extensive analysis of patenting trends. New information on international patenting trends of U.S. and foreign inventors in several important technologies is presented.

The role of small business in high-technology industries is then next, primarily through new information on the technology areas that seem to attract new business formations, generate employment and export activity, and attract foreign capital.

The chapter concludes with a presentation of new leading indicators that are designed to identify those countries with the potential to become more important exporters of high-technology products over the next 15 years. Current data availability limits this discussion to an examination of the high-tech potential of several Asian countries.

The Global Markets for U.S. Technology

In the United States, two parallel developments—the growing import penetration of the U.S. domestic market and the recent large U.S. trade deficits—have drawn attention to the country's ability to compete in an increasingly international economy. In particular, recent challenges to U.S. leadership in many high-technology product markets have led policymakers to examine the role of the Nation's S&T in supporting and restoring U.S. competitiveness in the global marketplace.

There are several reasons why high-tech industries are important to the U.S. economy.

- ◆ High-tech firms are associated with innovation. Firms that are innovative tend to gain market share, create new product markets, and/or use resources more productively. These characteristics have helped to make high-tech industries the fastest growing industries in the United States (ITA 1993, p. 21, tables 3 and 4).
- ◆ High-tech firms are associated with high value-added manufacturing and success in foreign markets which helps to support higher compensation to the production workers they employ.[3]
- ◆ Industrial R&D performed by high-tech industries has other "spillover" effects. These effects benefit other commercial sectors by generating new products and processes that can often lead to productivity gains, business expansions, and the creation of high-wage jobs (Tyson 1992; ITA 1993; and Hadlock, Hecker, and Gannon 1991).

This section discusses U.S. "competitiveness," broadly defined here as the ability of U.S. firms to sell products in the international marketplace. The concept of a nation's global competitiveness incorporates both its ability to export and compete against imports in the home market. The analysis in this section relies heavily on data compiled by the Organisation for Economic Co-operation and Development (OECD) and the U.S. Department of Commerce (DOC).

Throughout this section, industry-level data are presented for manufactured goods disaggregated by (1) those industries producing products that embody above average levels of R&D in their development (hereafter referred to as the ***high-technology industries*** and consisting of the aircraft, office and computing equipment, communications equipment, drugs and medicines, scientific instruments, and electrical machinery industries) and (2) all other manufacturing industries. (See "OECD High-Tech Industries.")

The Importance of High-Tech Production

High-technology goods are driving national economic growth in all of the major industrialized countries.[4] The global market for high-tech manufactured goods is growing at a faster rate than that for other manufactured

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[2] There is no single preferred methodology for identifying high-technology industries. The identification of those industries considered to be high-tech has generally relied on some calculation comparing R&D intensities. R&D intensity, in turn, has typically been determined by comparing industry R&D expenditures and/or numbers of technical people employed (i.e., scientists, engineers, technicians) to industry value added or the total value of its shipments. In this chapter, high-tech industries are identified using R&D intensities calculated by the Organisation for Economic Co-operation and Development.

[3] For more extensive data on average earnings, see BLS (1991) and Hadlock, Hecker, and Gannon (1991).

[4] The OECD member countries account for over 75 percent of global exports of manufactured goods and account for an even higher percentage of overall exports of high-technology goods (ITA 1985, p. 43). The 24 countries reporting to OECD are Australia, Austria, Belgium/Luxembourg, Canada, Denmark, Finland, France, Greece, Iceland, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States, and Germany.

Although the OECD data set does not include several nations of increasing importance in technology markets—most notably, the East Asian newly industrialized economies—it does provide a reasonable approximation of global commercial activity.

OECD High-Tech Industries

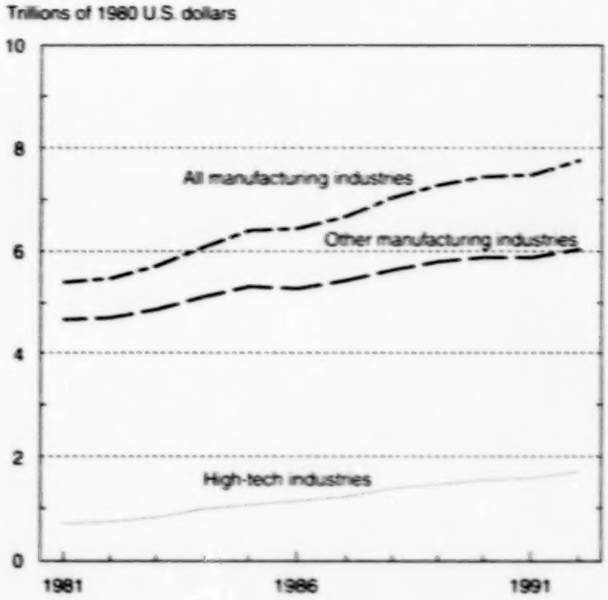
OECD identifies six industries as being high-tech based upon their high R&D intensities (R&D spending as a percentage of production) relative to other manufacturing industries. The OECD definition was established in 1986 using 1980 data. A review was conducted in 1992 and the rankings remained unchanged. Following are the six high-tech industries, their International Standard Industrial Classification codes, and their 1980 R&D intensities. Also included are similar data for the "other manufacturing industries" used throughout this chapter.

Industry	ISIC code	R&D intensity
High-technology		
Aircraft (Aerospace)	3845	22.7
Office & computing equipment	3825	17.5
Communications equipment	3832	10.4
Drugs & medicines	3522	4.8
Scientific instruments	385	4.8
Electrical machinery	383 excl. 3832	4.4
Other manufacturing		
Motor vehicles	3843	2.7
Chemicals	351 and 352, excl. 3522	2.3
Average for all other manufacturing industries		1.8

The OECD categorization used here is more restrictive than the Department of Commerce's DOC-3 high-technology system, which includes space technologies and ordnance as high-tech industries. (See ITA 1983.) Note that the other manufacturing category does not include agriculture or services.

goods. In constant dollar terms (1980),[5] production of high-tech manufactures by the major industrialized nations more than doubled from 1981 to 1992, while production of other manufactured goods grew by just 29 percent. (See figure 6-2 and appendix table 6-4.) Output by the high-tech industries represented under 14 percent of global production of all manufactured goods in 1981; by 1992, it represented 22 percent.

Figure 6-2.
Global production of manufactured products



See appendix table 6-4. *Science & Engineering Indicators – 1993*

In the increasingly competitive environment of the 1980s, the United States, Japan, and Europe moved resources toward the manufacture of higher value, technology-intensive goods. In 1989, U.S. high-tech manufactures represented 23 percent of total U.S. production of manufactured output, up from 15 percent in 1981. High-tech manufactures accounted for 16 percent of the European Community's total production in 1989, compared with 12 percent in 1981. But the Japanese economy led all other major industrialized countries in its economic reliance on the high-tech industries; this emphasis on high-tech manufacturing began to increase rapidly during the middle part of the decade. In 1981, high-tech manufactures represented nearly 17 percent of total Japanese production, rose to 22 percent in 1984, and then to 29 percent in 1989. (See figure 6-3.)

Data for the 1990s indicate a continued focus on high-tech manufactures among the industrialized countries. High-tech manufactures are estimated to represent 27 percent of U.S. manufacturing output in 1992, 31 percent of Japan's and nearly 17 percent for the European Community countries.[6]

Share of World Markets[7]

Throughout the 1980s and early 1990s, the United States was the world's leading producer of high-tech

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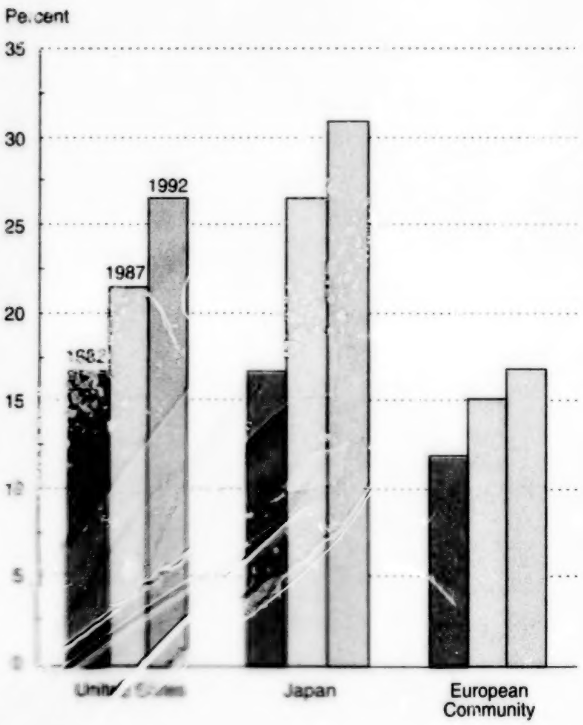
[5] The conversion into constant 1980 dollars is done in two steps:

1. Product-specific price changes are removed by deflating the current dollar series for each product category (for all countries) using the price index (1980 = 1.0) for the corresponding industry in DRI/McGraw-Hill's 430-sector inter-industry model of the U.S. economy.
2. All production series for a given country are multiplied by the ratio of the U.S. gross national product deflator to the gross domestic product deflator of that country to adjust for differences in the general rate of inflation.

[6] Data for 1991 and 1992 are estimates by DRI/McGraw-Hill.

[7] World market shares are calculated using data on OECD production contained in appendix table 6-4.

Figure 6-3.
High-tech industries' share of total manufacturing output



See appendix table 6-4. *Science & Engineering Indicators – 1993*

products, responsible for over one-third of total OECD member country production during this period. U.S. global market share did decline slightly from 1981 to 1986, but the trend was reversed beginning in 1987. The U.S. share of the world market for high-tech manufactures grew irregularly after 1986, but by 1992, U.S. high-tech industries were able to recapture the market share lost during the early eighties.

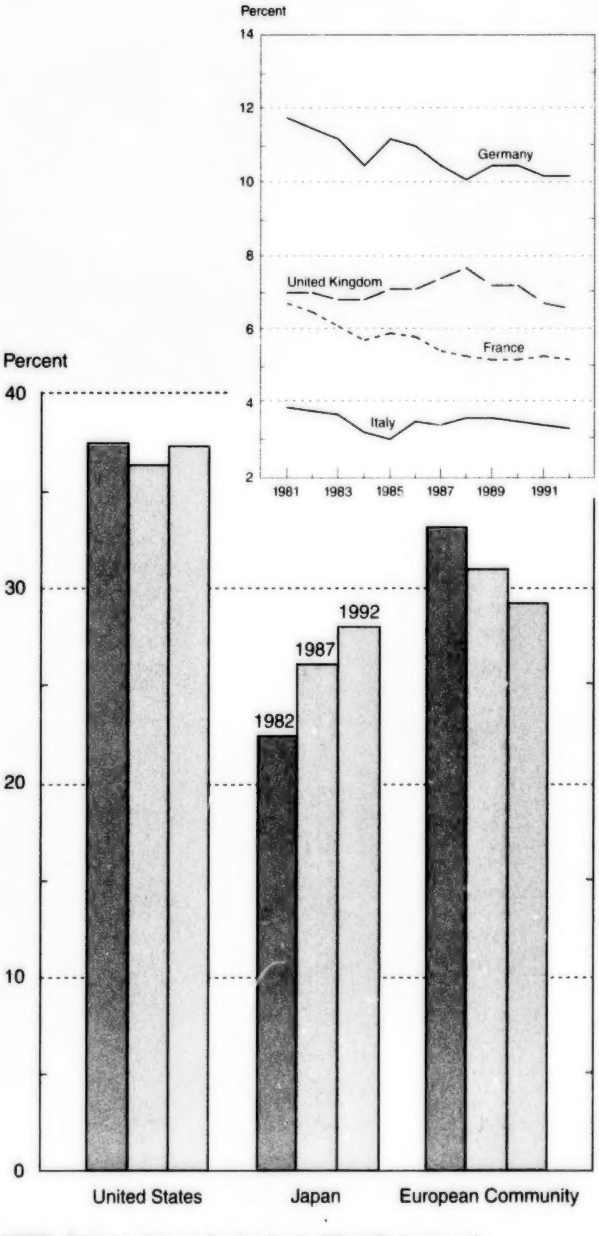
While U.S. high-tech industry struggled to maintain market share during the 1981-92 period, Japanese high-tech industries followed a path of steady gains in global market share. In 1992, Japan accounted for nearly 28 percent of OECD member country production of high-tech products, moving up 6 percentage points since 1981. (See figure 6-4.)

Japanese gains in global high-tech markets appear to have been made at the expense of European Community high-tech producers: Germany, France, and Italy all steadily lost market share between 1981 and 1992. British high-tech producers actually gained market share for most of the eighties before joining the general European high-tech decline in 1989. This decline continued into the early nineties, ultimately leaving British producers with a smaller share of OECD high-tech production in 1992 than it held in 1981.

Global Competitiveness of Individual Industries

The market competitiveness of individual U.S. high-tech industries varies. Of the six industries that form the high-tech group, three U.S. industries—those producing scientific instruments, drugs and medicines, and aircraft—gained global market share during the 1980s and maintained that market share into the early nineties. The U.S. computer and office equipment industry experienced the sharpest drop in global market

Figure 6-4.
Region/country share of global high-tech market



NOTE: German data are for the former West Germany only.

See appendix table 6-4. *Science & Engineering Indicators – 1993*

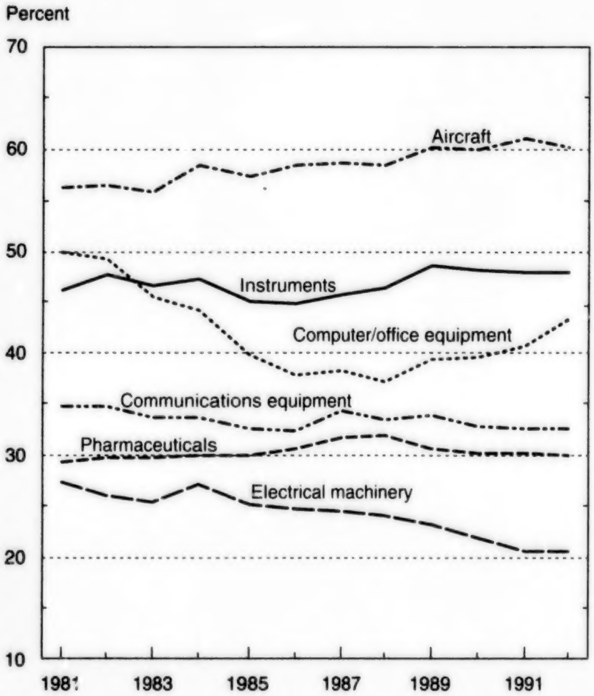
share of the six high-tech industries during the 1980s, but also rebounded with the greatest gain in market share in the early nineties. (See figure 6-5.)

As of 1992, the United States was still the world's leading producer in the following high-tech industries:

- aircraft (accounting for 60 percent of OECD production),
- scientific instruments (48 percent),
- computers and office equipment (43 percent), and
- pharmaceuticals (30 percent).

Where it once dominated high-tech markets both at home and abroad, U.S. leadership is now challenged on a variety of fronts. In the following sections, U.S. competitiveness is examined first in foreign markets and then in the U.S. home market.

Figure 6-5.
U.S. global market share, by high-tech industry

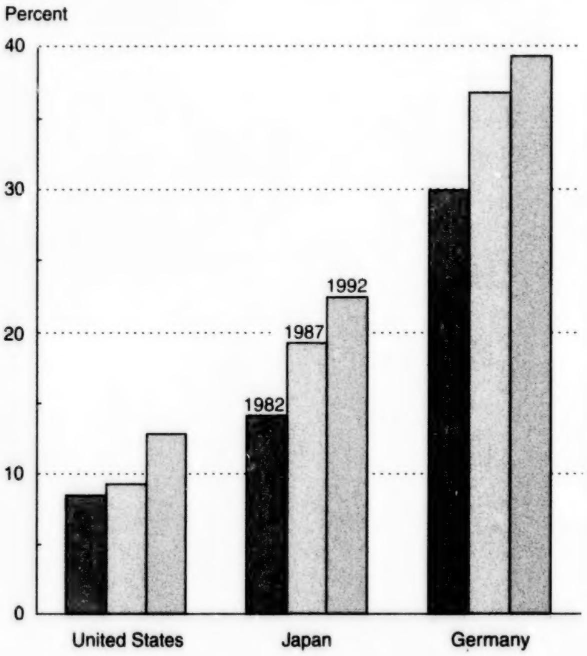


See appendix table 6-4. *Science & Engineering Indicators – 1993*

Exports Share of Total Manufacturing Production

Historically, the United States has not been an economy oriented toward serving foreign markets. In fact, in the United States, exports account for a smaller proportion of manufacturers' shipments than in any other industrialized economy. (See figure 6-6.) From 1981 to 1985, U.S. producers exported about 8 to 9 percent of total domestic production; this proportion rose to nearly 13 percent in 1992. By comparison, during this same period, Japanese producers exported 15 percent of that country's domestic production in 1981, 18 percent by 1986, and 22 percent by 1992. European Community manufacturers exported even higher percentages of domestic output. In 1981, European producers exported 31 percent of total production, over 38 percent in 1986, and nearly 48 percent by 1992.[8]

Figure 6-6.
Ratio of exports to production for all manufacturers



NOTE: German data are for West Germany only.
See appendix table 6-4. *Science & Engineering Indicators – 1993*

While U.S. producers have reaped many benefits from having the largest home market in the world, mounting trade deficits of the 1980s also generated concern about the need to expand U.S. exports. U.S. high-tech industries have traditionally been more successful than other U.S. industries in foreign markets. Consequently, high-tech industries have attracted considerable attention from policymakers as they seek ways to return the United States to a more balanced trade position.

Foreign Markets. Despite their domestic focus, U.S. producers are important suppliers of high-tech products in overseas markets. Still, the 1980s proved to be chal-

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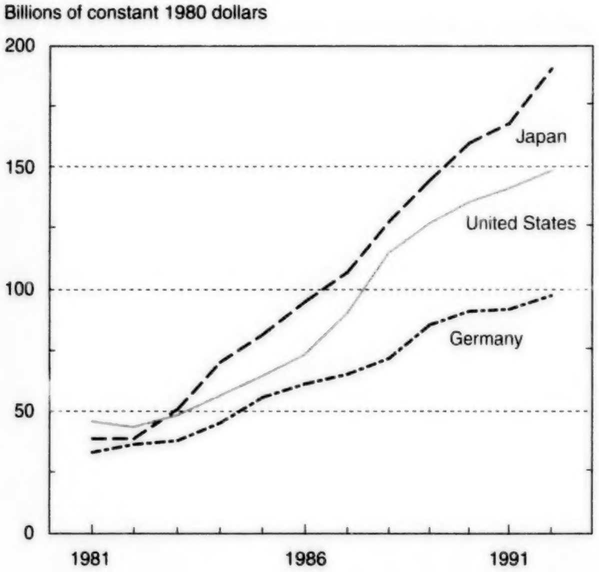
[8] These figures include trade between individual European nations. If data were available that excluded this intra-European trade, exports by European producers would represent a significantly smaller share of total output.

Figure 6-7.
High-tech exports



See appendix table 6-4. *Science & Engineering Indicators – 1993*

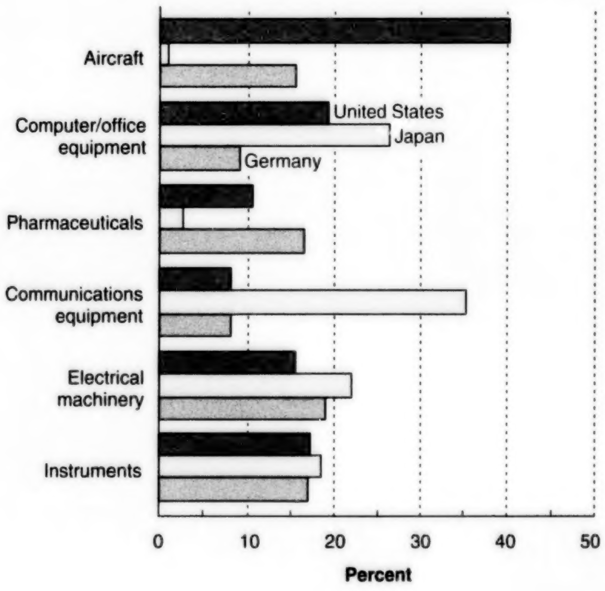
lenging, as the U.S. share of foreign markets dropped steadily from 23 percent in 1981 to 18 percent in 1986.[9] The strength of the U.S. dollar during the early eighties hampered U.S. competitiveness globally. But as a consequence, U.S. producers were driven to be more innovative, to improve product performance, and to increase manufacturing efficiency. Better products, coupled with a weakening dollar, led to a rise in foreign market share after 1986, and U.S. high-tech industries' share of OECD exports rebounded to 20 percent by 1988. However, an intensifying global economic slowdown and an appreciating U.S. dollar once again sidetracked U.S. export growth, and the U.S. foreign market share slipped to just below 18 percent in 1992.

The United States is no longer the world's leading exporter of manufactures produced by high-tech industries. Beginning in 1983, Japan surpassed the United States and Germany in overall high-tech exports and continued to lead by varying margins through 1992. (See figure 6-7.) In 1992, Japan accounted for 23 percent of OECD member country high-tech product exports, compared with 18 percent for the United States and 12 percent for Germany. European Community manufacturers have been responsible for 47 to 50 percent of OECD high-tech exports throughout the 1980s and early 1990s, although intra-European trade figures significantly in this calculation of the European share of OECD exports.

During the early eighties, nonhigh-tech U.S. industries, as a group, experienced similar difficulties in foreign markets. Throughout the 1981-92 period, U.S. high-tech industries held about twice the foreign market share of other U.S. manufacturing industries.

Industry Comparisons. During the 1980s and into the next decade, Japan successfully gained foreign market share in five of the six individual high-tech industries. By 1992, the United States led in only one industry—aircraft—with a 40-percent share of total OECD exports. Germany also led in only one industry in 1992, holding a 17-percent share of OECD exports of pharmaceuticals. The 1992 data show Japanese industry leading the industrialized world in exports in the other four high-tech industries. (See figure 6-8.)

Figure 6-8.
Export market share: 1992



See appendix table 6-4. *Science & Engineering Indicators – 1993*

U.S. Trade Balance

During the 1980s and into the early 1990s, the United States ran consistent trade *deficits*, importing more manufactured products than it was able to export. A strong U.S. dollar during the early eighties led to a rise in imported merchandise while exports remained stagnant. As the dollar weakened during the late 1980s, U.S. exports surged, growing at an average rate of nearly 14 percent per year during the 1985-89 period. U.S. demand for imports slowed somewhat during this period, allowing for a narrowing of the U.S. trade deficit. The U.S. merchandise trade deficit continued to narrow as the 1990s began, dropping to a 7-year low in 1991. Only one additional year of data was available, but it indicates a worsening of the deficit. (See figure 6-9.)

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[9] Foreign market shares are calculated using data on OECD country exports contained in appendix table 6-4.

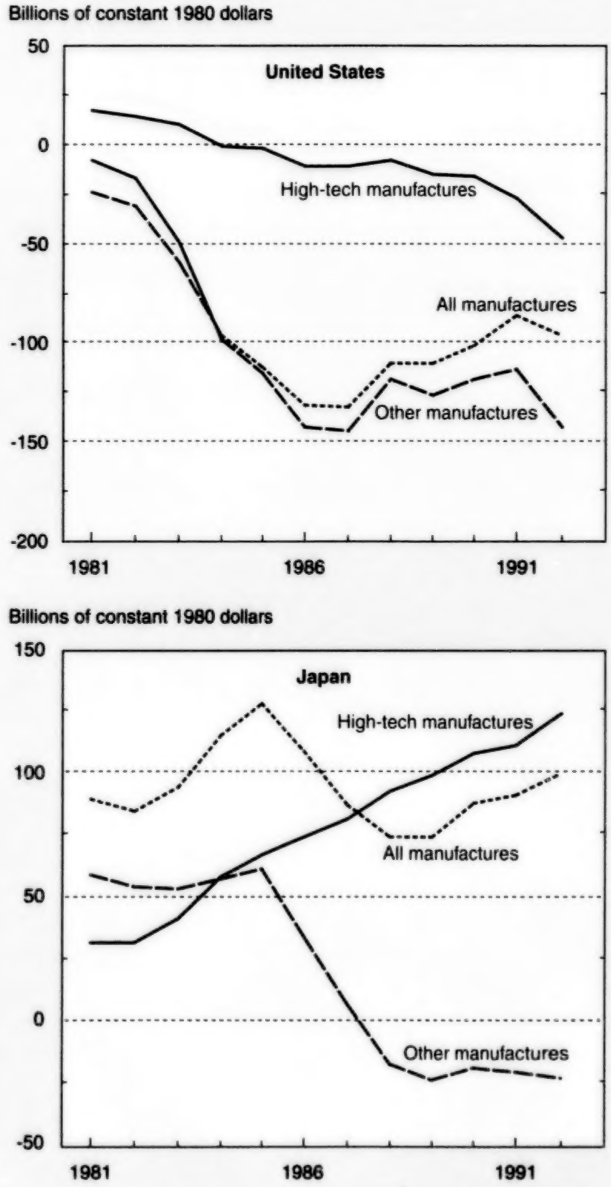
U.S. high-tech exports have traditionally overshadowed U.S. imports of high-tech products. Nevertheless, trade surpluses began to narrow during the 1980s and finally, in 1984, U.S. imports of foreign high-tech products exceeded U.S. high-tech exports.[10] The U.S. trade position in high-tech products improved in 1987 and 1988, but deteriorated quickly as the nineties began.

U.S. trade in nonhigh-tech products produced consistent trade deficits throughout the 12-year period examined (1981-92). As seen for U.S. trade in high-tech products, U.S. trade in all other products worsened (larger trade deficits) through the early and mid-1980s; it then improved (narrower deficits) in the latter part of the decade. Unlike trade in high-tech products, U.S. trade in other manufactures continued to produce narrower deficits in 1990 and 1991. By 1992, U.S. trade in nonhigh-tech products also began to produce a larger trade deficit.

Individual Industry Comparisons. The trend shown for the composite U.S. high-tech group masks strong performances by several U.S. high-tech industries. In three of the six high-tech areas, U.S. industry exports exceeded imports of like products throughout the 12-year period examined. (See figure 6-10.) The U.S. aircraft industry led all other U.S. high-tech industries' trade performance, generating consistent and widening trade surpluses. The U.S. scientific instruments industry registered a trade surplus in 1992 that exceeded any previously recorded surplus for this industry since 1981. The U.S. pharmaceutical industry has also found receptive markets overseas and contributed positively to the overall U.S. trade position consistently during 1981-92.

The remaining three high-tech areas had very different trade experiences. The United States ran a trade deficit in communications equipment and electrical machinery; this imbalance grew annually during the 1980s and continued to worsen through 1992. But trade in computer and office equipment showed the greatest deficit of all the high-tech areas. From 1981 to 1986, the United States exported more computer and office equipment than it imported. In 1986, that surplus declined sharply, priming an eventual turn to escalating deficits in the United States' computer and office equipment trade. Throughout the 12-year period examined, the growth in U.S. exports of computer and office equipment did not keep pace with U.S. imports. By 1992, this trend produced a $44 billion trade deficit—nearly three times the size of the U.S. trade surplus in aircraft equipment.

Figure 6-9.
Trade balance in manufactures



See appendix table 6-4. *Science & Engineering Indicators – 1993*

Trade Experience for Major Competitors. Japan alone among the United States' major competitors saw its trade in high-tech manufactures produce larger and larger surpluses during the 1980s and into the early 1990s. Its trade in other manufactures produced stable surpluses from 1981 to 1987, but then turned to a deficit position as imports of other products surged, overwhelming Japan's small but continuing export growth in these industries. (See figure 6-9.) These diverging trends once again illustrate Japan's nearly complete

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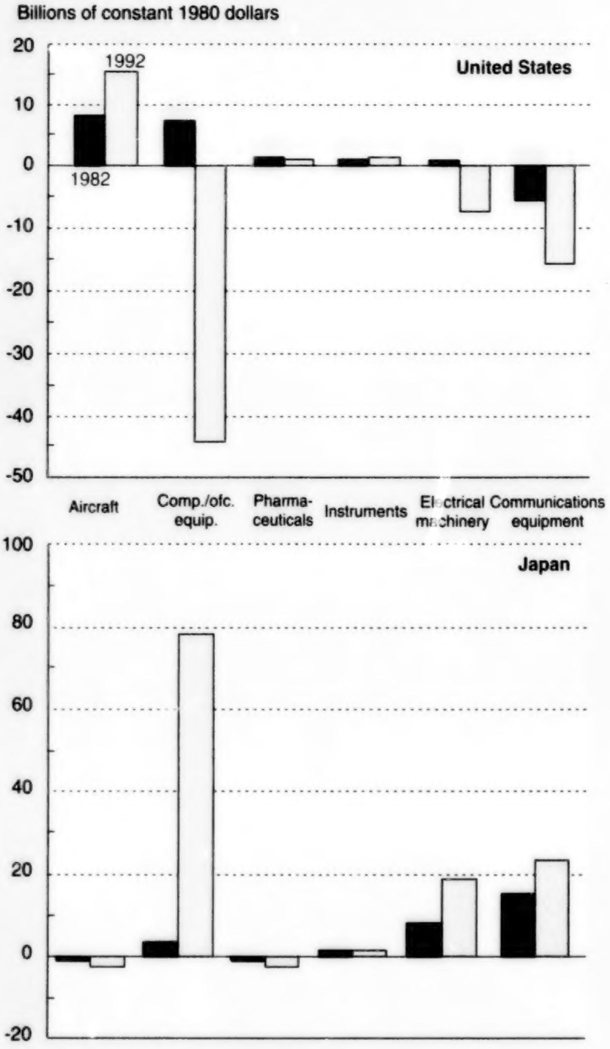
[10] Trade data (exports and imports) are available on a product-level basis; production data are not. To conform with the production and trade data used elsewhere in this chapter, the discussions of trade balances are based on industry-level data. The industry-level OECD definition of high-technology trade used here shows more midterm fluctuations and an earlier trade deficit for U.S. high-tech trade than trends portrayed using certain product-level definitions. See DOC (1983) and Abbott (1991) for technical discussions of alternative high-tech definitions.

Figure 6-10.
Trade balances for high-tech industries



See appendix table 6-4. *Science & Engineering Indicators – 1993*

conversion to an economy that has tied its future economic growth to the technology-intensive industries.

Concurrent with the erosion of the U.S. trade position in computer and office equipment has been the emergence of Japan as a global supplier of computer hardware-related products. In fact, the escalating trade surplus generated by Japan's high-tech industries as a group was largely driven by its computer and office equipment industry. Of the six industries included in the high-tech category, in 1992, Japan had a trade surplus in four (in order of contribution to its surplus in high-tech products): computer and office equipment, communications equipment, electrical machinery, and scientific instruments. (See figure 6-10.)

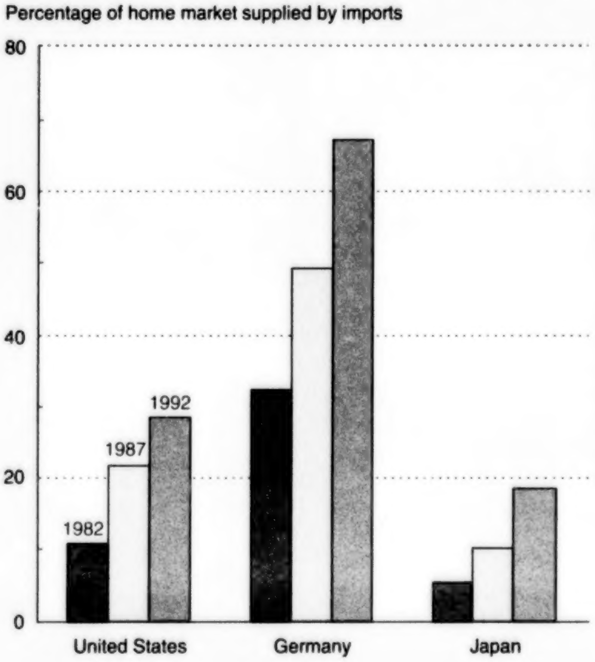
The Home Market

A country's home market is often thought of as the natural destination for its manufactured output. For obvious reasons—including proximity to the customer and common language, customs, and currency—marketing at home is easier than marketing abroad.

But in today's global marketplace, product origin may only be one factor among many influencing the consumer's choice between competing products—price, quality, and product performance will often be more important factors guiding product selection. Thus, in the absence of prohibitive trade barriers, the intensity of competition faced by domestic producers in their home market can approach, if not equal, the level of competition faced in foreign markets. Given the large size and appetite of the U.S. market, examination of U.S. competitiveness at home is critical to an understanding of the country's global competitiveness.

Import Penetration: High-Tech Markets. The United States represents the world's largest national market for high-tech products. During the 1980s, high-tech demand in the United States—as well as in the other major industrialized countries—was increasingly being met by foreign suppliers. (See figure 6-11 and appendix table 6-5.) Imports supplied about 11 percent of the U.S. demand for high-tech products in 1981; by 1989, this percentage rose to 26 percent and then to 28 percent by 1992. While U.S. producers still supply nearly 75 percent share of the large U.S. home market, these producers often count on supplying the home market in order to achieve the economies of scale that aid U.S. competitiveness in foreign markets.

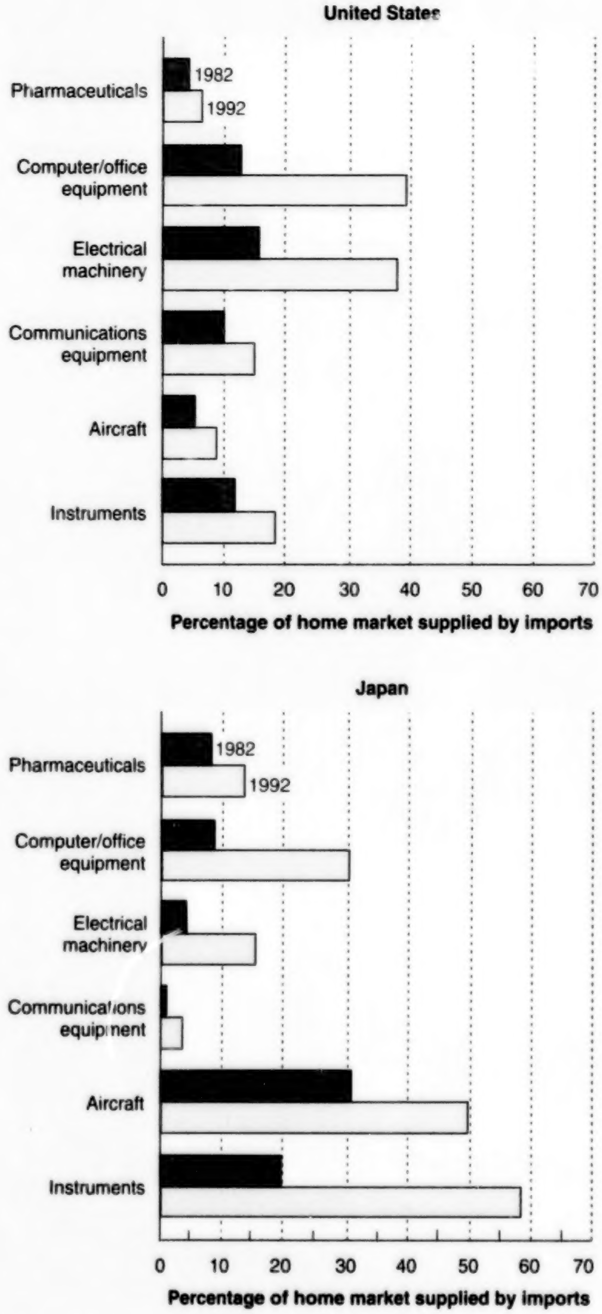
Figure 6-11.
Import penetration of high-tech markets



NOTE: German data are for the former West Germany only.

See appendix table 6-4. *Science & Engineering Indicators – 1993*

Figure 6-12.
Import penetration of six high-tech markets



See appendix table 6-5. *Science & Engineering Indicators – 1993*

The Japanese home market, historically the most self-reliant of the major industrialized countries, also increased its purchases of foreign technologies during the 1980s; this trend continued into the early 1990s. In 1981, imports of high-tech manufactures supplied 6 percent of Japanese domestic consumption, rising steadily to 15 percent by 1989, and to nearly 19 percent by 1992.

Progress toward the creation of a more economically unified market in Europe has fostered even greater trade among the economies of the European Community, the European Free Trade Association,[11] and more recently, with Eastern Europe countries.[12] Many of the reforms introduced to remove barriers hampering trade within Europe have also had the effect of making Europe an even more attractive market to the rest of the world.[13] Rapidly rising import penetration ratios in the major European economies during the later part of the 1980s and early 1990s reflect these changing circumstances and highlight greater trade activity in European high-tech markets when compared with product markets for less technology-intensive manufactures.

High import penetration ratios apparent during the late eighties and early nineties also reflect an increased trend in Europe toward cross-border production of capital and technology-intensive goods. The number of mergers and acquisitions involving Europe's largest firms rose sharply during the mid- to late 1980s and were heavily concentrated in Europe's manufacturing industries (ITC 1992, pp. 1-3 to 1-18). Among Europe's more technology-intensive industries, a large number of mergers and acquisitions have taken place in the chemical, machine tool, and electronics industries.[14]

Import Penetration: Closer Look at Japanese and U.S. Home Markets, by Industry. Both the U.S. and Japanese domestic markets have become increasingly internationalized in all high-tech industries. (See figure 6-12.) For example, during the 1980s, of the six high-tech industries examined, the U.S. computer and office equipment industry experienced the greatest rate of increase in import competition from other industrialized countries, but especially from Japan.[15] U.S. industry continues to dominate its home market for aircraft and pharmaceutical products.

During the 1980s, foreign suppliers gained a larger presence in several of Japan's high-tech markets. Foreign suppliers of aircraft and related products have traditionally been very successful in selling in Japan; that success was replicated in several other high-tech markets, especially after 1985. Imports increasingly supplied an expanded demand for computers and office equipment and scientific instruments in Japan. U.S. manufacturers of these high-tech products were particularly successful: U.S. manufacturers of computer and office equipment and of scientific instruments have not simply increased their market share in Japan, but have also continued to dwarf the market share gains made by suppliers from all other major industrialized countries.[16]

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[11] The European Free Trade Association is composed of Austria, Finland, Iceland, Norway, Sweden, Switzerland, and Liechtenstein.

[12] Trends in European trade are presented in ITC (1992).

[13] Efforts have been made to increase "harmonization" of national laws on intellectual property, customs controls, and rules governing product standards, testing, and testing procedures.

[14] For a discussion of international R&D alliances, see chapter 4.

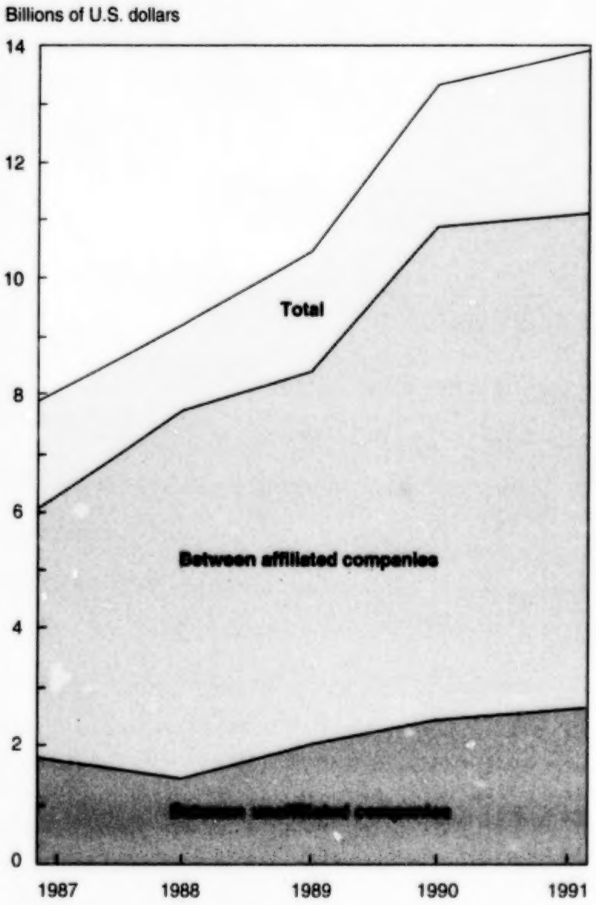
[15] Information on the source of imports is derived from product-level trade data.

Royalties and Fees Generated From Intellectual Property

The United States has traditionally maintained a large surplus in international trade of intellectual property. Trade in intellectual property includes the licensing and franchising of proprietary technologies, trademarks, and entertainment products. These transactions generate net revenues for U.S. firms in the form of royalties and licensing fees.

U.S. Royalties and Fees From All Transactions. U.S. receipts from all trade in intellectual properties approached $18 billion in 1991, nearly double U.S. firm receipts recorded just 5 years earlier. (See appendix table 6-6.) During the period 1987-91, U.S. firms' receipts were generally four to five times as large as U.S. payments to foreign firms for intellectual property. Most (about 75 percent) of these latter transactions involved exchanges of intellectual property between U.S. firms and their foreign affiliates. (See figure 6-13.) Exchanges of intellectual property between affiliates allow for a much higher level of control to the leasing firm. The frequency of such exchanges between related parties is growing faster than those between unaffiliated firms, suggesting greater internationalization of U.S. business.

Figure 6-13.
Royalties and fees: U.S. trade balance



See appendix table 6-6. *Science & Engineering Indicators – 1993*

U.S. Royalties and Fees From Trade in Technical Knowledge. Data on royalties and fees can be disaggregated to illuminate trends in technical knowledge. Receipts and payments for patents and technical knowledge are an indicator of firms' technological prowess. Transactions among unaffiliated firms—where prices are set through a market-related bargaining process—tend to reflect the exchange of technology and its market value at a given point in time. Unaffiliated transactions are generally subject to less owner control than transactions between affiliates. Therefore, examining the record of the resulting receipts and payments provides an indicator of the production and diffusion of technical knowledge.

The United States is a net exporter of technology sold as intellectual property. Royalties and fees received from foreign firms have been, on average, three times that paid out to foreigners by U.S. firms for access to their technology. U.S. receipts from such technology sales totaled $2.6 billion in 1991, up from $1.7 billion in 1987. (See figure 6-14 and appendix table 6-7.)

Japan is the largest consumer of U.S. technology sold in this manner. In 1991, Japan accounted for 47 percent of all such U.S. receipts, while the Western European countries (i.e., the European Community) together represented 18 percent. South Korea increased its purchases of U.S. technological know-how sharply during the 5 years for which data are available. It became the second largest consumer of U.S. industrial processes with a 9-percent share in 1991, up from just a 2-percent share in 1987.

To a large extent, the U.S. surplus in the exchange of intellectual property is driven by trade with Japan and the newly industrialized Asian economies. In 1991, U.S. receipts (exports) from technology licensing transactions were 11 times U.S. firm payments (imports) to Japan. On the other hand, the U.S. trade surplus with Europe in sales of technological know-how declined over the past 5 years (1987 to 1991). Germany represented the largest European trading partner in these transactions; moreover, it was the only country in the world with which the United States had a persistent technical knowledge trade deficit.

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[16] This information on Japan's source of imported computers and office equipment, scientific instruments, and other high-tech products is extracted from OECD Trade Series C data processed by DRI/McGraw-Hill under contract to the National Science Foundation.

International Trends in Industrial R&D[17]

The industrial sector is the main source of the new technologies and products that aid national economic competitiveness. In high-wage countries like the United States, industries stay competitive in a global marketplace through innovation. Innovation can lead to better production processes and better performing products (i.e., more durable, more economical, etc.); it can thereby provide the competitive advantage high-wage countries require when competing with low-wage countries.

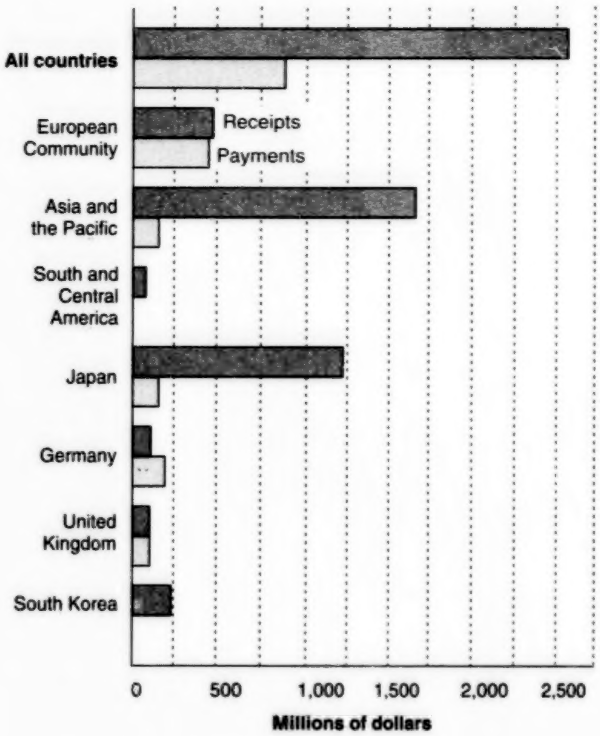
Research and development activities provide an incubator for new ideas that lead to new processes, products—and even new industries. While not the only source of new innovations, R&D activities conducted in industry-run laboratories and facilities are associated with many of the important new ideas that have helped shape modern technology.[18] U.S. industries that traditionally conduct large amounts of R&D have met with greater success in foreign markets than less R&D-intensive industries and have been more supportive of higher wages for their employees.[19]

This section examines R&D trends using a database developed at OECD. It describes trends in all industrial R&D performed from 1973 through 1990, regardless of the source of its funding.[20] The discussion begins with a comparison of overall trends in industrial R&D activity. This analysis is followed by a discussion of trends in the top R&D-performing manufacturing industries in the United States and in those of our two major competitors in the global marketplace, Japan and Germany.

Overall Trends

The United States has long led the industrialized world in the performance of industrial R&D. Over the past two decades, however, U.S. dominance has been challenged. The U.S. share of total industrial R&D performed by the OECD countries fell between 1973 and 1990. (See figure 6-15.) Despite this decline, the United States remains the leading performer of industrial R&D by a wide margin, even surpassing the combined R&D of the 12-nation European Community.

Figure 6-14.
U.S. royalties and fees generated from the exchange of industrial processes between unaffiliated companies: 1991



NOTE: U.S. payments to South and Central America and to South Korea were less than $500,000.

See appendix table 6-7. *Science & Engineering Indicators – 1993*

Japan underscored its belief in the economic benefits of investments in R&D by following a high R&D growth path that led to a near doubling of its share of total OECD R&D during the period examined. Germany, the third leading performer of industrial R&D, also closed the gap between itself and the United States, but only slightly when compared to Japan. Italy and Canada were the only other two countries that showed somewhat higher than average growth in industrial R&D between 1973 and 1990; the United Kingdom and France join the United States in below average growth.[21]

R&D Performance by Manufacturing Industries

The United States, Japan, and Germany represent the three largest economies of the industrialized world and compete head to head in many manufacturing industries. An analysis of R&D data provides some explanation for past national success in certain of these industries and can also signal shifts in national technology priorities.[22]

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[17] Data from OECD's Structural Analysis Database for Industrial Analysis, Analytical Business Enterprise R&D file (STAN/ANBERD) are used to examine trends in total industrial R&D. This database tracks all R&D expenditures (both defense- and nondefense-related) carried out in the industrial sector regardless of funding source. For an examination of U.S. industrial R&D by funding source, see chapter 4.

[18] While an important indicator of innovative activity, there is ample evidence that suggests that many new ideas and technological improvements are being developed outside of the R&D "lab." In order to develop better indicators of innovation activities, the National Science Foundation is preparing to conduct a national survey of innovation activities in U.S. industry. This new survey initiative has evolved after many years of empirical study both in the United States and in Europe. The new U.S. survey has been constructed in collaboration with other OECD members and the results will provide a better understanding of the innovation process in the United States and in other major industrialized countries.

[19] See "The Global Markets for U.S. Technology" for a presentation of recent trends in U.S. competitiveness in foreign and domestic product markets.

[20] These data are not categorized by type of R&D performed (i.e., basic, applied, or development). Both defense- and nondefense-related R&D conducted in the industrial sector are included in these data.

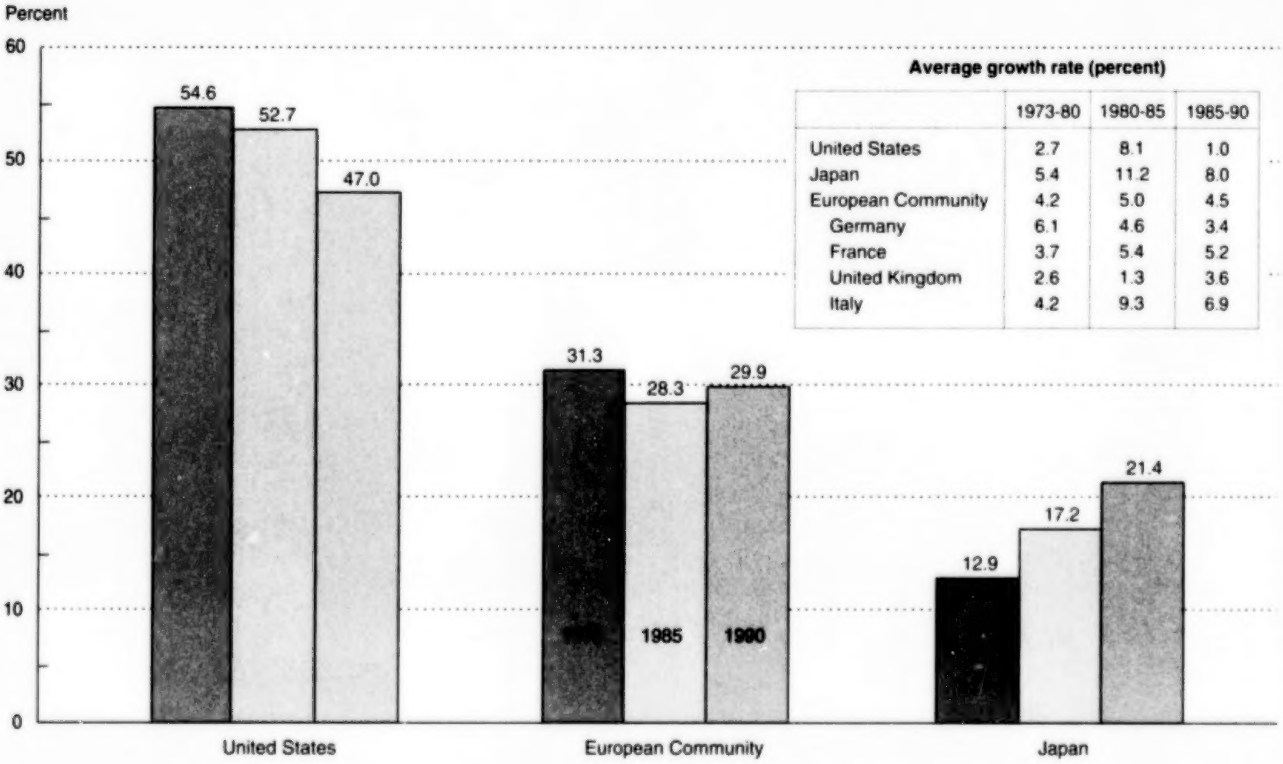
[21] International comparisons of total industrial R&D are calculated in terms of purchasing power parity (PPP) dollars and growth rates are based on 1985 constant prices. For more information on PPPs, see chapter 4.

R&D performance (spending) by eight manufacturing industries is examined—aircraft, computer and office equipment, communications equipment, pharmaceuticals, instruments, scientific instruments, motor vehicles, chemicals, and electrical machinery. These eight industries include all the top performers of industrial R&D in the United States, Japan, and Germany. They also happen to have the highest "R&D intensity" among manufacturing industries in the OECD countries as a group.[23]

The United States. R&D performance in U.S. manufacturing industries followed a pattern of rapid growth during the 1970s, rising an average of 11 percent per year between 1973 and 1980 (2.7 percent per year in 1985 constant prices). This growth pattern accelerated during the early eighties, before slowing down considerably during the latter part of the decade. The eight industries account for over 80 percent of total industrial R&D performed in the United States; they therefore drive R&D trends in the U.S. industrial sector.

The U.S. aircraft and communications equipment industries have consistently been the largest performers of R&D. (See figure 6-16 and appendix table 6-8.) Comparing R&D performance in 1973 and 1990, shows some shifting in R&D emphasis among the top five industry performers. Although the aircraft and communications equipment industries retain their top positions as the leading R&D performers in the United States, R&D growth in the motor vehicle and electrical machinery industries did not keep pace with that in the computer and office equipment industry during the period examined. Consequently, by

Figure 6-15.
Shares of total industrial R&D performed in OECD countries



Average growth rate (percent)

	1973-80	1980-85	1985-90
United States	2.7	8.1	1.0
Japan	5.4	11.2	8.0
European Community	4.2	5.0	4.5
Germany	6.1	4.6	3.4
France	3.7	5.4	5.2
United Kingdom	2.6	1.3	3.6
Italy	4.2	9.3	6.9

NOTES: Data were calculated using purchasing power parities; growth rates are based on 1985 constant prices. German data for the former West Germany only.

SOURCE: The Organisation for Economic Co-operation and Development, Structural Analysis Database for Industrial Analysis, Analytical Business Enterprise R&D (STAN/ANBERD) file (Paris: 1992).

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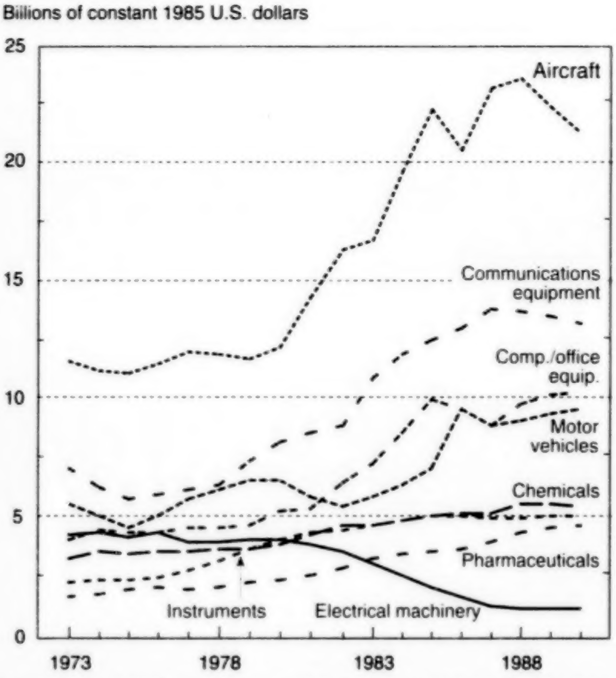
[22] Industry-level data are occasionally estimated in order to provide a complete time series for the 1973-90 period.

[23] Only six industries were included in the high-tech group discussed earlier with regard to market competitiveness. For the group of OECD countries, these six had substantially higher R&D intensities (R&D as a share of total output) than did the motor vehicle industry and the chemicals industry and therefore were not included in OECD's group of high-tech industries. (See "OECD High-Tech Industries" for individual industry R&D intensities.)

Figure 6-16.
U.S. industrial R&D performance



Top industrial R&D performers and their share of total industrial R&D

1973		1980		1990	
Aircraft	24.6	Aircraft	21.6	Aircraft	24.6
Comm. equip.	14.9	Comm. equip.	14.4	Comm. equip.	16.5
Motor vehicles	11.7	Motor vehicles	11.6	Comp./office equip.	12.8
Elect. machinery	8.9	Comp./office equip.	9.3	Motor vehicles	11.9
Comp./office equip.	6.4	Elect. machinery	7.1	Chemicals	6.8

See appendix table 6-8. *Science & Engineering Indicators – 1993*

1990, the computer and office equipment industry became the third leading r&d performer in the United States. (See figure 6-16.)

Japan. Since 1973, R&D performance in Japanese manufacturing industries grew at a higher annual rate than in the United States, and faster than all other industrialized countries since 1980. Japanese industry continued to expand its R&D spending rapidly through 1985, more than doubling the annualized rate of growth seen during the 1970s. Japanese industrial R&D spending slowed somewhat during the second half of the 1980s, but still led all other industrialized nations in terms of average growth in industrial R&D.

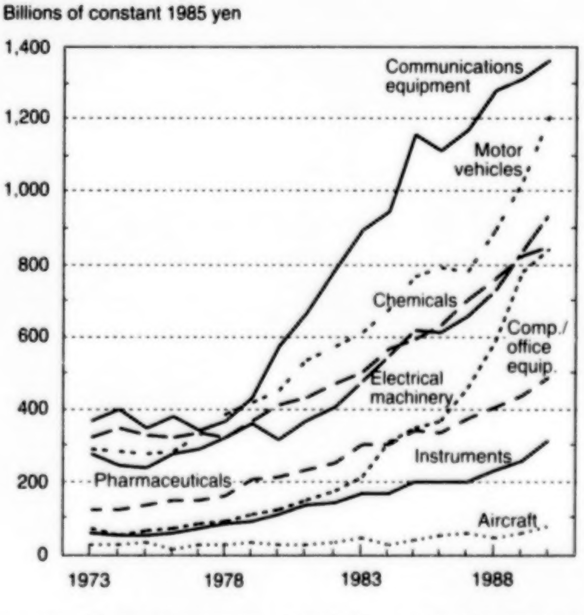
The eight industries examined here together accounted for between 66 and 72 percent of total industrial R&D performed in Japan during the 1973-90 period, compared with over 82 to 88 percent in the United States. This suggests a wider role for R&D in Japan's industrial sector (outside the eight industries examined) than seen in the United States.

An examination of the top five R&D-performing industries in Japan reflects that country's long emphasis on communications technology (including consumer electronics, high-definition TV, and all types of audio equipment). This industry was the leading performer of R&D throughout the period reviewed. Japan's motor vehicle industry was the third leading R&D performer in 1973, but rose to number two in 1980 and remained at that level through 1990. (See figure 6-17 and appendix table 6-9.) Japanese automobiles earned a reputation for high quality and economy during these years, which earned Japanese auto makers larger and larger shares of the global car market.

Electrical machinery producers also are among the largest R&D performers in Japan and have maintained high R&D growth throughout the period examined. By contrast, the U.S. electrical machinery industry saw its ranking among the top U.S. R&D producers in the United States decline since 1973. Japan's industry, on the other hand, moved up to become that country's third leading R&D-performing industry in 1990.

Another Japanese industry that has become a more important R&D performer is the computer and office equipment industry. Japan's computer and office equipment industry did not rank among the top five R&D performers until 1984. But rapid R&D growth during the late seventies and throughout the eighties moved this industry ahead of

Figure 6-17.
Japan's industrial R&D performance



Top industrial R&D performers and their share of total industrial R&D

1973		1980		1990	
Comm. equip.	15.9	Comm. equip.	17.2	Comm. equip.	16.3
Chemicals	14.0	Motor vehicles	13.5	Motor vehicles	14.4
Motor vehicles	12.4	Chemicals	12.4	Elect. machinery	11.2
Elect. machinery	11.9	Elect. machinery	9.4	Chemicals	10.1
Pharmaceuticals	5.2	Pharmaceuticals	6.4	Comp./office equip.	10.0

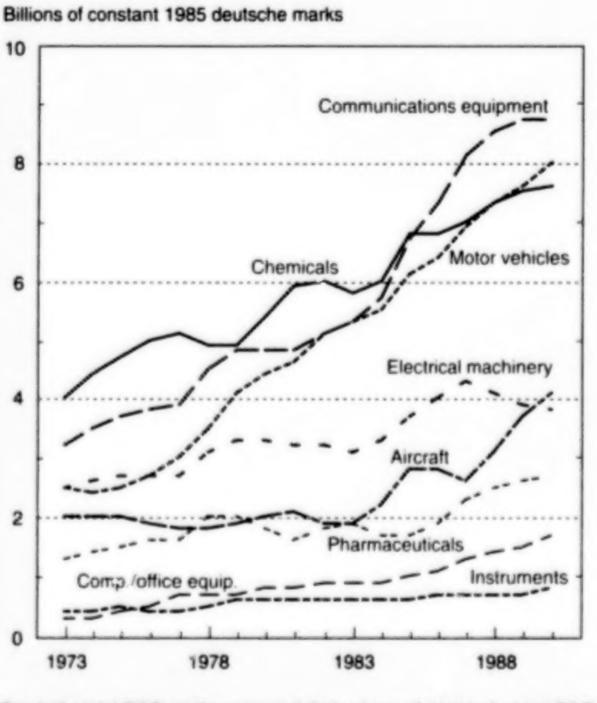
See appendix table 6-9. *Science & Engineering Indicators – 1993*

Japan's pharmaceutical industry: the industry has maintained this position through 1990. (See figure 6-17.)

Germany. During the 1970s (1973-80), German industry led the industrialized world in R&D growth (when calculated in constant purchasing power parities). During the 1980s, while much of the industrialized world tended to focus even more resources on industrial R&D, German industrial R&D growth slowed down. In fact, German R&D grew even slower during the second half of the decade than it did during the already sluggish growth period of the early 1980s.

Total German industry R&D appears to be somewhat less concentrated among the eight industries examined than in the United States, but more so than in Japan. The same five industries have led German industry in R&D performance. (See figure 6-18 and appendix table 6-10.) From 1973 to 1985, the German chemical industry led all other German industries in total R&D performed. The communications equipment industry was the second leading performer during this time. In 1986, the German communications equipment industry became its number one R&D-performing industry, even surpassing Germany's chemical industry (a traditional strong R&D performer in Germany) and has retained that position through 1990.

Figure 6-18.
Germany's industrial R&D performance



Top industrial R&D performers and their share of total industrial R&D

1973		1980		1990	
Chemicals	20.2	Chemicals	17.8	Comm. equip.	18.7
Comm. equip.	16.3	Comm. equip.	15.7	Motor vehicles	17.1
Elec. machinery	12.7	Motor vehicles	14.3	Chemicals	16.4
Motor vehicles	12.5	Elec. machinery	10.9	Aircraft	8.9
Aircraft	10.0	Aircraft	6.6	Elec. machinery	8.2

See appendix table 6-10. *Science & Engineering Indicators – 1993*

An examination of those other industries that were among the top five R&D performers in Germany mirrors that country's commercial prominence as a supplier of world-class machinery and motor vehicles. During the second half of the 1980s, the German computer and office equipment industry and its pharmaceutical industry have shown the most rapid R&D growth among the eight industries.[24] (See 6-18.)

Patented Inventions[25]

One of the important benefits of R&D is a stream of new technical inventions that may in turn be embodied in innovations—i.e., in new or improved products, processes, and services. Inventors can obtain government-sanctioned property rights by applying for patents. Such patents are issued by authorized government agencies for inventions judged to be new, useful, and nonobvious.[26]

Patent data provide useful indicators for measuring technical change and inventive input and output over time (see Griliches 1990). Further, U.S. patenting by foreign inventors enables measurement of the levels of invention in those foreign countries (Pavitt 1985) and can serve as a leading indicator of new technological competition (Faust 1984).[27] Patent statistics trends can therefore serve as an indicator—albeit one with certain limitations—of national inventive activities.[28]

This section describes broad trends of patent activity in the United States over time, by field, and by industry by both U.S. and foreign inventors. It discusses patenting trends in foreign countries and presents new data on international patenting trends in "critical" technologies.

Granted Patents by Owner

Patents Granted to Americans.[29] Over the past 15 years, the number of patents awarded to American inventors

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[24] R&D performance by European Community manufacturers is presented in appendix table 6-11.

[25] Although the U.S. Patent and Trademark Office grants several types of patents (e.g., design patents), this discussion is limited to *utility* patents, which are commonly known as "patents for inventions."

[26] A patent grant allows an inventor to ***exclude others from making, using, or selling that invention***. See Patent and Trademark Office (1989).

[27] Corporations account for about 80 percent of all foreign-owned U.S. patents.

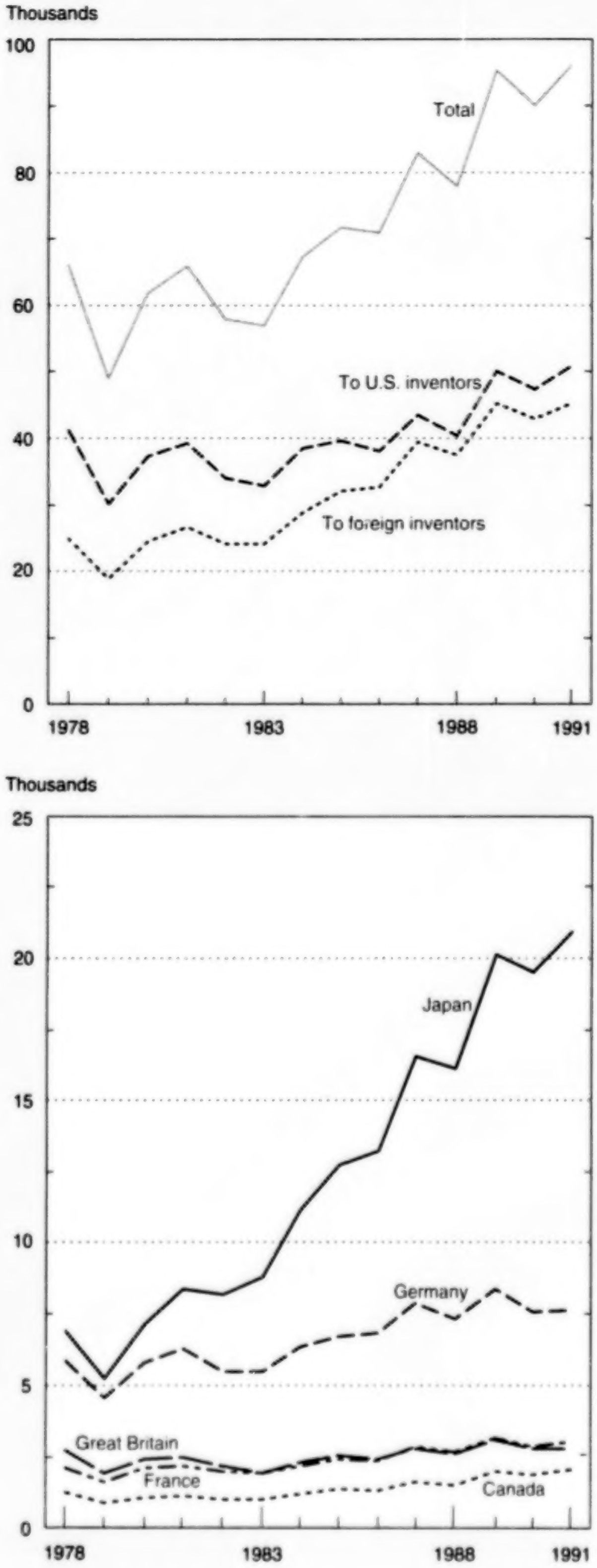
[28] Patenting indicators have some well-known drawbacks, including the following:

- *Incompleteness*—many inventions are not patented at all, in part because laws in some States already provide for the protection of industrial trade secrets.
- *Inconsistency across industries*—industries vary considerably in their propensity to patent inventions; consequently, it is not advisable to compare patenting rates between different technologies or industries.
- *Inconsistency in quality*—the inventions patented can vary considerably in quality. (Patent citation rates, discussed on p. 178, are one method for dealing with this question of varying quality.)

Despite these and other limitations, patents provide a unique and convenient source of information on inventive activities.

[29] The U.S. Patent and Trademark Office grants patents to both U.S. and foreign inventors. Patent origin is determined by the residence at the time of grant of the first-named inventor as specified on the face of the patent. Patents "granted to Americans" are actually U.S. origin patents.

Figure 6-19.
U.S. patents granted, by nationality of inventor



NOTE: German data are for the former West Germany only.

See appendix table 6-12. *Science & Engineering Indicators – 1993*

has followed two different trends. From 1978 through 1983, the number of patents granted to Americans declined irregularly.[30] Since 1983, the number of patents granted to Americans picked up, and has remained on a general upward trend. In 1991, the latest year for which statistics are available, U.S. origin patenting registered a new high when nearly 51,000 patents were granted to U.S. resident inventors. Foreign patenting in the United States also reached new highs in the post-recession period (1983-91) and grew at a quicker rate than did U.S. domestic patenting—8.2 versus 5.6 percent per year.[31] (See figure 6-19 and appendix table 6-12.)

Patents granted to American inventors can be further analyzed by patent ownership at the time of grant. Inventors who work for private companies or for the Federal Government commonly assign ownership of their patents to their employer; self-employed inventors usually retain ownership of their patents. The owner's sector of employment is thus a good indication of the sector in which the inventive work was done. In 1991, 71 percent of granted patents were owned by corporations.[32] (See figure 6-20.) This percentage has not changed significantly over the years.[33]

Individuals are the next largest group of U.S. origin patent owners. Prior to 1978, individuals owned a quarter of all patents granted.[34] Their share rose to 27 percent in 1980 and was 26 percent in 1991. The federal share of patents averaged 3.5 percent of total during the period 1963-77; thereafter, U.S. Government-owned patents as a share of total U.S. origin patents has declined.[35] Finally, only about 1 percent of patents granted to American inventors are owned by foreign corporations or governments.

In 1991, the number of patents granted in the United States rose nearly 8 percent.[36] U.S. inventors received 53 percent of the U.S. patents granted that year, representing a small increase in share of U.S. patents awarded to Americans. Before 1989, foreigner inventors were patenting in the United States at a faster pace than U.S. resident inventors. That trend stalled in 1989 and 1990, and was reversed in 1991 as American inventors' U.S. patent success outpaced that of foreign inventors.

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[30] The number of patents granted to all countries dipped in 1979 because the Patent Office could not afford to print all the patents approved that year.

[31] Both U.S. and foreign patenting declined from 1987 to 1988. This decline, one of many oscillations that appear in patenting data by year of patent grant, may be due to the especially low number of patents awarded in 1986 because of budget restrictions at the Patent Office. This development, in turn, led to an unusually high number of patent grants in 1987 as patents were carried over into that year. Also, utility patent applications dropped in 1983. Since it can take 2 to 3 years before a successful application matures into a patent, this drop may also have contributed to the low number of patent grants in 1986.

[32] About 2.6 percent of patents granted to Americans in 1991 were owned by U.S. universities and colleges. The Patent Office counts these as being owned by corporations. For further discussion of academic patenting, see chapter 5, "Patents Awarded to U.S. Universities."

[33] Between 1978 and 1991, corporate-owned patents accounted for between 69 and 73 percent of total American-owned patents.

[34] Prior to 1978, data are provided as a total for the period 1963-77.

[35] Federal inventors frequently obtain a statutory invention registration (SIR) rather than a patent. An SIR is not ordinarily subject to examination and costs less to obtain than a patent. Also, an SIR gives the holder the right to use the invention, but does not prevent others from selling or using the invention as well.

[36] Part of this increase may be attributed to the ongoing efforts by the Patent Office to reduce "pendency," the time between receipt of a patent application and completion of its processing.

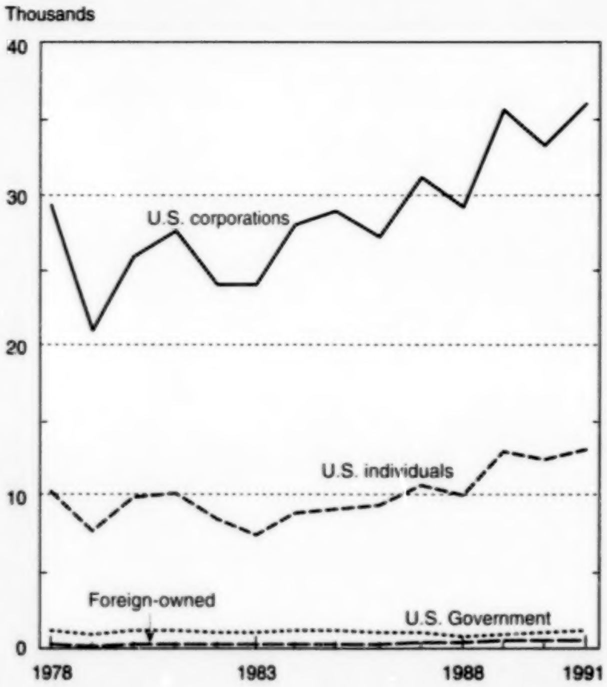
The number of patents awarded to Americans in 1991 represented the first upturn in U.S. share of granted patents since 1977. The increase in U.S. share is a reflection of the successes of individual inventors and of a rise in U.S. Government-owned patents. Increased patent activity by government agencies was encouraged by legislation enacted during the 1980s which called for U.S. agencies to establish new programs and increase incentives to its scientists, engineers, and technicians in order to improve the transfer of technology developed in the course of government activities.[37]

Patents Granted to Foreign Inventors. Foreign-owned patents represent nearly half (47 percent in 1991) of all patents granted in the United States. Moreover, the number of U.S. patents granted to foreign inventors increased in 1991, although the increase was smaller than that reported for those with U.S. origin (a 5.3-percent increase versus 7.6 percent). In 1991, foreign corporations owned nearly 82 percent of the foreign-origin U.S. patents, individuals owned 11 percent, and foreign governments owned just 1 percent. Since 1978, corporate ownership of foreign-origin U.S. patents has grown in importance as the share owned by individuals has declined.

Foreign patenting in the United States is highly concentrated by country of origin. In 1991, just five countries—Japan, Germany, Great Britain, France, and Canada—accounted for 80 percent of U.S. patents granted with foreign origin. (See figure 6-19.) The numbers of patents granted to inventors from these countries have generally increased. Of these five countries, only the Japanese share grew over the past 14 years. This growth, however, has been dramatic, with Japanese inventors receiving 22 percent of all U.S. patents in 1991 and 46 percent of all U.S. patents with foreign origin. In 1978, these shares were under 11 percent and 28 percent, respectively.

Patent shares accounted for by inventors from the top three European countries generally declined over the past 14 years: German inventors were granted 24 percent of U.S. patents with foreign origin in 1978; this share fell to 17 percent in 1991. The British share fell the most among the top three European countries, dropping from 11 percent in 1978 to 6 percent in 1991. Canadian inventors' share of U.S. patents granted declined in the late seventies and early eighties before showing evidence of reversing this trend in 1987 with small gains made in 1989 and 1991.

Figure 6-20.
U.S. patents granted, by sector of owner



See appendix table 6-12. *Science & Engineering Indicators – 1993*

Comparing foreign patenting growth rates in the United States in the wake of the 1980s recession reveals the expanding roles of Japan and Europe as technology competitors and also identifies several other countries with a demonstrated capacity to generate new technologies. During the 1983-91 period, the average U.S. patenting growth rate was 8.2 percent per year among inventors from all foreign countries. Countries whose inventors demonstrated above average patent activity in the United States and also claimed over 100 patents in 1991 were

- South Korea, 40.8 percent growth in patents per year (401 U.S. patents granted in 1991);
- Taiwan, 38.8 percent per year (898 patents);
- Spain, 15.0 percent per year (153 patents);
- Israel, 13.7 percent per year (305 patents);
- Japan, 11.4 percent per year (20,916 patents);
- Finland, 9.3 percent per year (328 patents); and
- Canada, 9.2 percent per year (2,030 patents).

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[37] The Stevenson-Wydler Technology Innovation Act of 1980 made the transfer of federally owned or originated technology to state and local governments, and to the private sector, a national policy and the duty of each government laboratory. The act was amended by the Federal Technology Transfer Act of 1986 to provide additional incentives for the transfer and commercialization of federally developed technologies. Later, Executive Order 12591 of April 1987 ordered executive departments and agencies to encourage and facilitate collaboration among federal laboratories, state and local governments, universities, and the private sector—particularly small business—in order to aid technology transfer to the marketplace.

During this same period, several other countries' inventors showed above average patent activity in the United States. These included

- Hong Kong, 17.0 percent per year (49 U.S. patents granted in 1991);
- Brazil, 15.5 percent per year (60); and
- Ireland, 15.0 percent per year (55 patents).

The patenting growth rate for the United States during this time was 5.6 percent per year (50,895 patents).[38]

Patents by Patent Office Classes[39]

A country's distribution of patents by technical area provides a key to understanding that country's contribution to important fields of technology. This section compares and discusses the various key technical fields favored by inventors from various countries in their U.S. patenting.

Fields Favored by U.S., Japanese, and German Inventors. While *U.S. patent activity* spans a very wide spectrum of technology and new product areas, U.S. corporations' patenting also shows a particular emphasis on several of the technology areas that are expected to play an important role in future national economic growth (National Critical Technologies Panel 1993). In 1991, U.S. inventors were granted patents on inventions related to high-performance computing, telecommunications, electricity transmission, devices for the manufacture of semiconductors, and superconductor technology. U.S. patent activity also reflects this country's natural resource endowment and the economic importance gained from more effective extraction and use of these resources.[40] The strength of U.S. chemical and biomedical industries is evident from the large number of patents assigned to U.S. corporations in these areas. (See text table 6-1 and appendix table 6-13.)

Japanese patenting in the United States appears to focus on technologies and products related to several commercially important industries. The 1991 patent data show Japanese inventors emphasizing those technology classes associated with the motor vehicle, photography, and photocopying industries. (See text table 6-1 and appendix table 6-14.) But also increasingly evident is the wider range of U.S. patents awarded to Japanese inventors in information technology. From improved information storage technology for computers to improved optic systems, Japanese inventions are earning U.S. patents in areas that will facilitate the expansion, storage, and transmission of information.

German inventors continue to develop new products and processes in technology areas associated with the heavy manufacturing industries in which Germany has traditionally maintained a large presence. The 1991 U.S. patent activity index shows German emphasis on the printing, chemicals, steel, motor vehicle, and power generation-related patent classes. (See text table 6-1 and appendix table 6-15.) But, like the Japanese, German inventors have not ignored the new technology areas that may dictate an expansion of its industrial sector's future competitiveness. Germany's U.S. patenting activity also indicates that its inventors are developing new products and processes that would fall within biotechnology and optoelectronic technology areas.

Fields Favored by Other Major Industrialized Countries. Like the United States, *Canada* is a large, resource-rich country: Its patent activity in the United States reflects these national characteristics. Canadian inventions patented in the United States are no doubt influenced by the need to find better ways to extract its oil and minerals and the need for better telecommunications across its vast land area. (See text table 6-2 and appendix table 6-16.) Also, its proximity to the United States and close ties with U.S. industry are evidenced by the similar concentrations of patent activity for the two countries.

French patent activity in the United States emphasizes nuclear technology and communications. (See text table 6-2 and appendix table 6-17.) The French also show high activity in biotechnology fields—an area in which the French already provide considerable competition for U.S. biotech firms.

The *British* are also quite active in the biotechnology patent classes and communication technologies; they share the U.S. emphasis on aeronautics as well. (See text table 6-2 and appendix table 6-18.) Like the Germans, the British do not patent much in the United States in semiconductor manufacturing, nor do they particularly patent in areas of Japanese emphasis, such as dynamic information storage and retrieval and photography.

Fields Favored by Newly Industrialized Economies. Patent activity by NIEs in the United States can be seen as an indicator of these economies' technological development and as a leading indicator of those product markets likely to see increased competition.

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[38] Note that, despite the dramatic recent increase in patent activity by the newly industrialized economies of East Asia—particularly Taiwan and South Korea—these countries, as a group, accounted for just 1.4 percent of all U.S. patents granted in 1991 and under 3 percent of U.S. patents granted to foreign inventors.

[39] Information in this section is based on the Patent and Trademark Office's classification system which divides patents into approximately 370 active classes. Using this system, patent activity for U.S. and foreign inventors in recent years can be compared by developing an *activity index*. This index measures a country's patenting activity within a given class. For any given year, the activity index is the proportion of patents in *a particular class* granted to inventors in a specific country divided by the proportion of *all* patents granted to inventors in that country.

Because U.S. patenting data reflect a much larger share of patenting by individuals without corporate or government affiliation than do data on foreign patenting, only patents granted to *corporations* are used to construct the U.S. patenting activity indexes.

[40] Research on the history of U.S. innovation (Abramovitz 1986 and, more recently, Mowery and Rosenberg 1993) also finds natural resource endowments to have a strong influence on a country's pattern of innovation.

Text table 6–1.
Top 15 most emphasized U.S. patent classes for inventors from the United States, Japan, and Germany

	United States	Japan	Germany
1.	Mineral oils: processes and products	Dynamic information storage or retrieval	Printing
2.	Chemistry, hydrocarbons	Photography	Chemistry, fertilizers
3.	Wells	Photocopying	Organic compounds[1]
4.	Chemistry—analytical & immunological testing	Dynamic magnetic information storage or retrieval	Organic compounds[1]
5.	Food or edible material: processes, compositions and products	Typewriting machines	Organic compounds[1]
6.	Superconductor technology—apparatus, material, process	Radiation imagery chemistry—process, composition or products	Ammunition and explosives
7.	Error detection/correction & fault detection/recovery	Recorders	Bearing or guides
8.	Amplifiers	Pictorial communication; television	Winding and reeling
9.	Chemistry: molecular biology and microbiology	Static information storage and retrieval	Brakes
10.	Drug, bio-affecting & body treating compositions	Active solid state devices, e.g., transistors, solid state diodes	Compositions, coating or plastic
11.	Chemistry, lignins or reaction products thereof	Sewing	Synthetic resins or natural rubber[2]
12.	Synthetic resins or natural rubber[2]	Music	Internal-combustion engines
13.	Compositions	Motor vehicles	Typewriting machines
14.	Electrical transmission or interconnection systems	Internal-combustion engines	Chemistry, inorganic
15.	Electricity, conductors and insulators	Image analysis	Synthetic resins or natural rubber[2]

[1] Part of the class 532-570 series.

[2] Part of the class 520 series.

See appendix tables 6-13, 6-14, and 6-15.

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Text table 6–2.
Top 15 most emphasized U.S. patent classes for inventors from Canada, France, and Great Britain

	Canada	France	Great Britain
1.	Metallurgy	Induced nuclear reaction, systems & elements	Drug, bio-affecting & body treating compositions
2.	Chemistry, inorganic	Wave transmission lines & networks	Joints and connections
3.	Electricity, conductors and insulators	Brakes	Chemistry, fertilizers
4.	Plastic article or earthenware shaping or treating	Organic compounds[1]	Metal fusion bonding
5.	Multiplex communications	Organic compounds[1]	Optical waveguides
6.	Chemistry—analytical & immunological testing	Communications, directive radio wave systems & devices	Aeronautics
7.	Telephonic communications	X-ray or gamma ray systems or devices	Organic compounds[1]
8.	Static structures, e.g., buildings	Glass manufacturing	Pulse or digital communications
9.	Supports	Pipe joints or couplings	Drug, bio-affecting & body treating compositions
10.	Mineral oils: processes and products	Communication, electrical: acoustic wave systems & devices	Wells
11.	Apparel	Organic compounds[1]	Brakes
12.	Wells	Chemistry, inorganic	Conveyors, power-driven
13.	Chemistry, electrical current producing apparatus, product and process	Registers	Glass manufacturing
14.	Material or article handling	Electricity, circuit makers and breakers	Compositions
15.	Cleaning and liquid contact with solids	Aeronautics	Communications, directive radio wave systems & devices

[1] Part of the class 532–570 series.

See appendix tables 6–16, 6–17, and 6–18.

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Taiwan illustrates the movement of NIEs toward new technology development and improvement of previously established technologies. (See text table 6-3 and appendix table 6-19.) As recently as 1980, Taiwanese patent activity in the United States was predominantly in the area of toys and other amusement devices. By 1991, Taiwan was active in more highly technical classes, gaining U.S. patents in such areas as communications technology, semiconductor manufacturing processes, and internal combustion engines. (See NSB 1991, chapter 6.) The latest data now show that inventors from Taiwan have added superconductor technology to their list of patent classes.

Text table 6–3.
Top 15 most emphasized U.S. patent classes for inventors from Taiwan and Korea

	Taiwan	Korea
1.	Locks	Electric lamp & discharge devices
2.	Superconductor technology: apparatus, material, process	Semiconductor device manufacturing process
3.	Closure fasteners	Static information storage & retrieval
4.	Metallurgy	Telephonic communications
5.	Amusement and exercising devices	Pictorial communication; television
6.	Semiconductor device manufacturing process	Electrical transmission or interconnection systems
7.	Electricity, conductors & insulators	Dynamic magnetic information storage or retrieval
8.	Electricity, circuit makers & breakers	Pulse or digital communications
9.	Error detection/correction & fault detection/recovery	Electric heating
10.	Electrical connectors	Gas separation
11.	Brushing, scrubbing & general cleaning	Registers
12.	Metal deforming	Joints and connections
13.	Illumination	Multiplex communications
14.	Telephonic communications	Electric lamp and discharge devices, systems
15.	Pumps	Active solid state devices, e.g., transistors, solid state diodes

See appendix tables 6–19 and 6–20.

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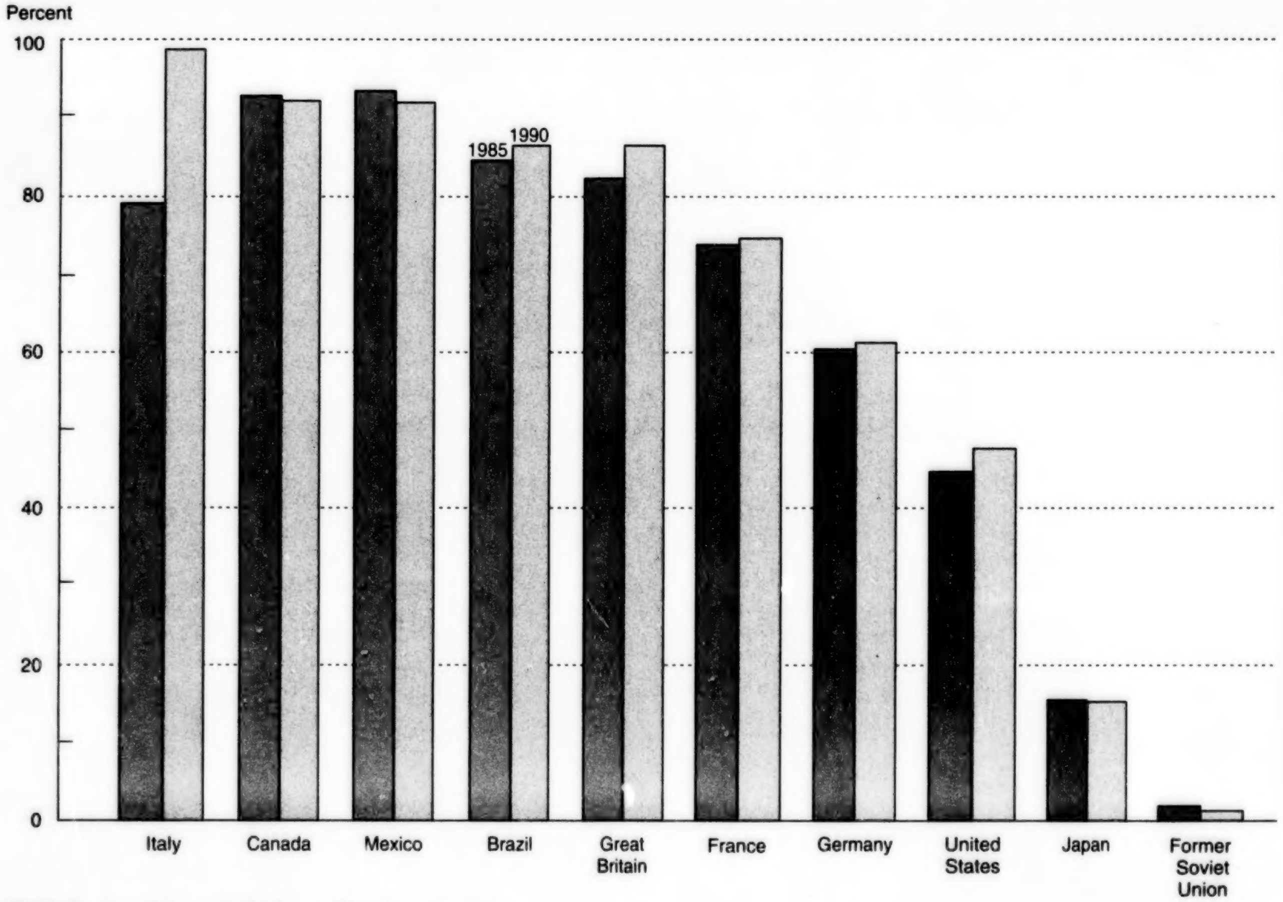
U.S. patenting by *South Korean* inventors is heavily concentrated in the patent classes that include electrical products and electronic component technologies. (See text table 6-3 and appendix table 6-20.) South Korea is also very active in such commercially significant technologies as semiconductor devices and computer peripheral equipment. In fact, South Korea is already a major supplier of computers and peripherals to the United States, and these

Figure 6-21.
Share of total patents awarded to nonresident inventors



NOTE: German data are for the former West Germany only.

See appendix tables 6-12 and 6-21.

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patent activity data show that the country's inventors may be developing the improvements that will support South Korea's future competitiveness in these technologies.[41]

Patenting Outside the United States

In most parts of the world, foreign inventors account for a much larger share of total patent activity than is the case in the United States. When foreign patent activity in the United States is compared with that in 11 other important countries during the years 1985 through 1990, only the former Soviet Union—with under 2 percent of its patents awarded to foreign inventors—and Japan—with around 15 percent—had less foreign patent activity. (See figure 6-21 and appendix table 6-21.) The long pendency period (6 to 7 years) in Japan and Japanese industry's practice of filing large numbers of applications claiming minor technical improvements to rival patentees' core technology tend to discourage foreign patenting (GAO 1993).

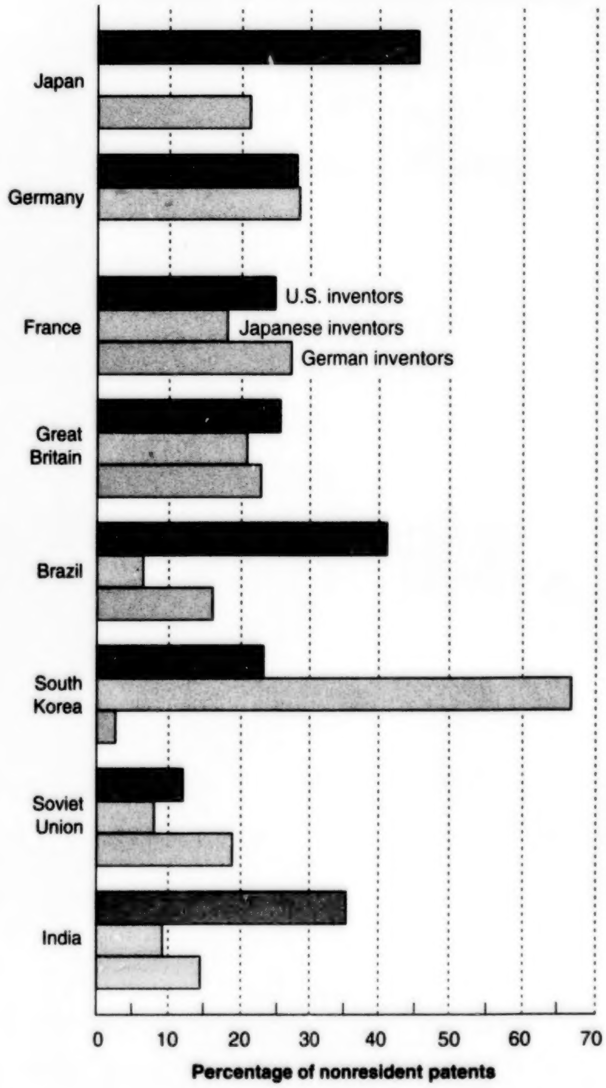
What is often obscured by the rising trends in foreign-origin patents in the United States is the success and widespread activity of U.S. inventors in patenting their inventions around the world. U.S. inventors lead all other foreign inventors not just in countries neighboring the United States (Canada and Mexico) or in those as close culturally as Great Britain, but also in Japan, Brazil, and India. (See figure 6-22.) Two of the United States' major competitors show similar global patenting activity. Japanese inventors edge out Americans in Germany and dominate foreign patenting in South Korea. German inventors lead all foreign inventors in France and the former Soviet Union; they are also quite active in all of the other countries examined.

International Patenting Trends for Three Important Technologies[42]

This section explores the relative strength of America's technological position by examining international patenting patterns in the critical technologies of advanced manufacturing, biotechnology, and information technology.[43] To facilitate patent search and analysis, these broad technology areas were each represented by a narrower subfield: robot technology was used as a proxy for advanced manufacturing, genetic engineering (recombinant DNA—RDNA—techniques) was used for biotechnology, and optical fibers were used to represent patent activity in information technology.[44] To ensure maximum comparability of data, the unit of analysis used in this discussion is built around the concept of a "patent family"—i.e., all the patent documents published in different countries associated with a single invention. (See "International Patent Families as a Basis of Comparison.")

In this section, three indicators are used to compare national positions in each critical technology.

Figure 6-22.
Patents granted to nonresident inventors, by granting country: 1990



NOTE: German data are for the former West Germany only.

See appendix table 6-21. *Science & Engineering Indicators – 1993*

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[41] South Korea was the fifth largest foreign supplier of computers and peripherals to the United States in 1989. See ITA (1991), p. 28-2.

[42] Data in this section are drawn from a database containing patent records from 33 major patenting countries, which facilitates a more comprehensive assessment of the U.S. technological position vis-à-vis other national competitors. These data were developed under contract for the National Science Foundation by Mogee Research & Analysis Associates; they were extracted from the World Patents Index database published by Derwent Publications, LTD.

[43] The technology areas selected for this study met several criteria:

- Each appeared on the lists of critical technologies considered important to future U.S. economic competitiveness or national security. (See Mogee 1991.)
- Each is characterized by the output of patentable products or processes.
- Each could be defined sufficiently to permit construction of accurate patent search strategies.
- Each yielded a sufficient population for statistical analysis.

[44] These subfields were identified based on a review of recent critical technologies reports and extensive consultation with National Science Foundation staff and experts in the technologies to determine representative subfields.

International Patent Families as a Basis of Comparison

A *patent family* consists of all the patent documents published in different countries associated with a single invention. The first application filed anywhere in the world is the *priority application*: it is assumed that the country in which the priority application was filed is the country in which the invention was developed. Similarly, the *priority year* is the year in which the priority application was filed. The *basic patent* is the first patent or patent application published in any of the 33 countries covered in the database used in this section. This database, the World Patents Index Latest, covers basic patents published from 1981 to the present.

Counts of patent families over time as an indicator of technological activity are skewed by those countries with national patent systems that encourage large numbers of patent applications (e.g., Japan). To eliminate this bias wherever possible, international patent families are used as a basis of comparison. An international patent family is created when patent protection is sought in at least one other country besides the one in which the earliest priority application was filed.

- *Trends in international inventive activity:* This indicator provides a first measure of the extent and growth of each nation's inventive activity important enough to be patented outside of the country of origin. These data are tabulated by priority year. (See "International Patent Families as a Basis of Comparison" for definition.) Since 18 months usually separate the patent filing date from the date of publication, available data may be incomplete prior to 1980 and after 1990; therefore, the period examined is 1980 to 1990.[15]

- *Highly cited inventions:* Interpatent citations are an accepted method of gauging the technological value or significance of different patents.[16] These citations, provided by the patent examiner usually on the front page of a patent document, indicate the "prior art"—i.e., the technology in related fields of invention—that was taken into account in judging the novelty of the present invention.[17] The number of citations a patent receives from later patents serves as an indicator of the original patent's technical importance or value. The technological significance indicator used here attempts to assess a country's contribution toward advancing the particular field of technology by determining the number of patent families from each priority country that are highly cited.[18] "Highly cited" in this case means the top 1 percent of families in terms of the number of citations received. To normalize differences in number of patent families, a country's share of highly cited patents are divided by its share of total patent families.

- *International patent family size:* Given the significant costs associated with obtaining patent protection in multiple countries, it can be assumed that the number of countries in which protection has been sought is an indicator of the perceived commercial potential of an invention. An indicator of relative national rankings of commercial potential is calculated by comparing mean family size for international patent families by priority country.[19]

Robot Technology

Robot technology, a high-visibility facet of advanced manufacturing, is easily associated with this broader technology sector. For this study, robot technology was defined as program-controlled manipulators, including the manipulator, program control, gripping heads, joints, arm sensors, safety devices, and accessories; and excluding nonprogram-controlled manipulators, prosthetic devices, and toy robots.[20]

International Patenting Activity. An examination of international patenting trends during the 1980-90 decade highlights the rapid growth taking place in the development of robot technology. The number of international patent families with priority applications in the seven countries examined (the United States, Japan, West Germany, East Germany, France, Great Britain, and South Korea) rose quickly and steadily from 1980 to 1988 before slowing down in the following 2 years. Patenting activity by this seven-country group accounts for about 65 percent of all families in this technology area.

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[15] In many countries, patent applications are published, automatically, 18 months after the priority filing.

[16] Carpenter, Narin, and Woolf (1981) show that technologically important U.S. patents on average receive twice as many examiner citations as does the average U.S. patent, thus helping to confirm the validity of interpatent citation as an indicator of patent quality. Albert, Avery, Narin, and McAllister (1991) show that citation counts prove to be a useful tool in identifying commercially important patents.

[17] The citations counted are those placed on patents filed with the European Patent Office (EPO) by EPO examiners, since EPO citations are believed to be a less biased and broader source of citations than those of the U.S. Patent and Trademark Office. See Claus and Higham (1982).

[18] Citation data are based on the *total* number of patent families, not just the *international* families.

[19] Operationally, this means counting the number of countries in a family in which a patent publication (i.e., a published patent application or an issued patent) exists.

[20] The trends discussed for robot technology are estimates based on a sample of 2,357 records drawn from a population of 10,203 records listed in Derwent's World Patent Index Latest (WPIL) database. The population consisted of all WPIL robot technology records with basic patent publications published in 1981 through mid-1993 and priority applications in the United States, Japan, West Germany, East Germany, France, Great Britain, and South Korea. The sampling method was random sample, stratified by priority country. The seven countries accounted for about 64.4 percent of total robot technology families. The then-Soviet Union accounted for about another 28 percent, but was not included because of incomplete data associated with that country's breakup.

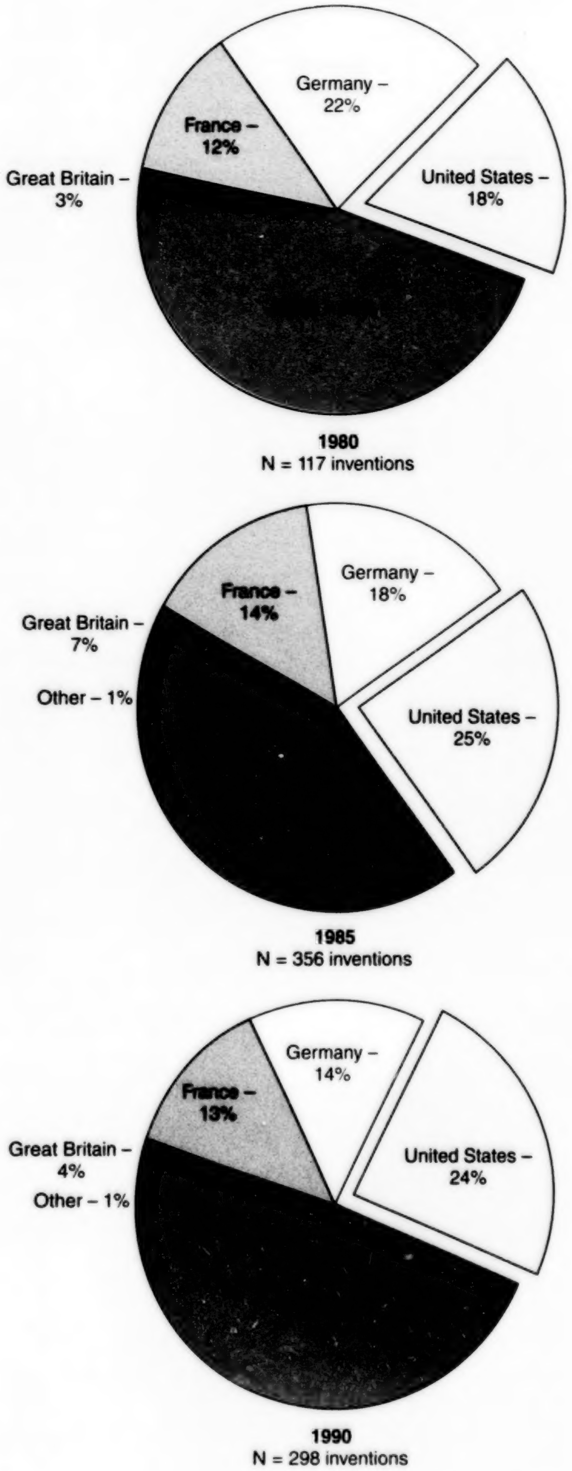
The conventional perception of Japan as an innovator in the area of advanced manufacturing techniques is reinforced by the large number of robot inventions for which Japanese firms have sought international patent protection. Japan led all other countries in the total number of international patent families in robot technology created during the entire 1980-90 period. (See figure 6-23 and appendix table 6-22.) Japan held 39 percent of the 3,264 international patent families created during this decade, followed by the United States (23 percent), West Germany (17 percent), France (12 percent), and Great Britain (6 percent).

Rankings for Japan and the United States change somewhat when the total number of foreign applications associated with each country's robot technology is considered. Looking at the entire 1981-90 period, the United States ranks slightly ahead of Japan (28 versus 27 percent), but the United States overtakes Japan only after U.S. firms doubled their foreign patent activity in robot technology in the 1986-90 period compared with 1981 to 1985. Japanese firms also increased their foreign patent activity in the latter half of the decade, but not to the extent recorded for the United States. (See text table 6-4.)

Data were also compiled for the former East Germany and South Korea. While East Germany showed considerable domestic patent activity involving robot technology, that same level of technological activity is not evident when data on international families are examined. This may reflect their isolation from trade with the Western world. Data for South Korea show only a few domestic patents, and South Korean companies have sought international patent protection for nearly all of these robot inventions. This indicates a high interest in international commercialization common to trade-based economies of newly industrializing countries like South Korea.

Highly Cited Inventions. Japan led all countries—and by a wide margin—with 67.5 percent (36 of 53) of all highly cited robot technology patents[51] generated during the 1981-85 period. France (with 11.2 percent of the highly cited patents), West Germany (9.8 percent), and the United States (9.6 percent) trailed distantly. (See appendix table 6-23.) Japan and France each had about 1.6 times the number of highly cited inventions as expected based on their levels of activity (i.e., their total numbers of families). (See text table 6-5.) West Germany, the United States, and Great Britain did not produce the

Figure 6-23.
Robot technology: Share of international patent families, by priority year and country



NOTES: An international patent family is created when patent protection is sought outside of the patenting country. German data are for the former West Germany only.

See appendix table 6-22. *Science & Engineering Indicators – 1993*

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[51] Operationally, these included all families with priority application dates from 1981 to 1985 with five or more citations, and those with priority application dates from 1986 to 1990 with two or more citations.

Text table 6–4.
Robot technology: Total number of foreign patents, by priority country

Priority Country	1981–85		1986–90		1981–90	
	Number of foreign patents	Country share of total	Number of foreign patents	Country share of total	Number of foreign patents	Country share of total
Total	6,692	100.0	10,387	100.0	17,079	100.0
United States	1,584	23.7	3,193	30.7	4,777	28.0
Japan	1,948	29.1	2,627	25.3	4,575	26.8
West Germany	1,359	20.3	1925	18.5	3,284	19.2
France	1,059	15.8	1,890	18.2	2,949	17.3
United Kingdom	696	10.4	664	6.4	1,360	8.0
East Germany	46	0.7	56	0.5	102	0.6
South Korea	0	0.0	32	0.3	32	0.2

NOTE: Patent population is estimated.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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expected number of highly cited inventions. Specifically, West Germany produced only 80 percent of what might be expected based on the number of inventions it produced during this period, and the United States and Great Britain produced about half of what was expected. Japan and France thus appear to have contributed a disproportionate number of important robot inventions relative to their level of inventive activity.

In the 1986-90 time period, the United States caught up with Japan in terms of number of highly cited families: Each country had nearly 41 percent of highly cited families for that time. Rankings for the other countries did not change substantially. Although the United States and Japan each had the same share of highly cited families, this represented a much larger share for the United States when adjusted for level of activity. The United States had twice the number of highly cited inventions as would be expected based on its share of all families, while Japan fell short (producing 90 percent of what was expected). This suggests that even though Japan had a higher number of robot inventions, U.S. inventions were more technologically important.

Text table 6–5.
Robot technology: Citation index

Priority country	Citation ratio	
	1981–85	1986–90
United States	0.5	2.1
Japan	1.6	0.9
France	1.6	1.2
West Germany	0.8	0.6
Great Britain	0.4	0.6
East Germany	0.0	0.0
South Korea	0.0	0.0

NOTE: The citation index is derived from the priority country's share of highly cited patent families divided by its share of total patent families.

See appendix table 6–23. *Science & Engineering Indicators – 1993*

Mean International Patent Family Size. When mean international patent family size is calculated for robot technology, France and Great Britain show the highest levels of perceived commercial value based on this measure. Those robot inventions originating in France and Great Britain for which patent protection has been sought in at least one other country have a mean patent family size of 8.5 and 7.9 countries, respectively, closely followed by the United States (7.4 countries) and West Germany (6.9 countries). Japan's and South Korea's international robot patent families tended to be much smaller. (See text table 6-6.)

The United States again shows surprising strength in this indicator, especially in light of the fact that the countries it trails are all located in Western Europe and have many commercial, locational, and historical ties that facilitate multiple-country patenting. The move toward European unification has also encouraged wider patenting

Text table 6–6.
Robot technology: Number of international patent families and average family size

Priority country	Number of families	Average family size
France	435	8.5
Great Britain	205	7.9
United States	833	7.4
West Germany	587	6.9
Japan	1,321	4.0
South Korea	12	3.2
East Germany	56	2.8

NOTE: Patent family size is determined by the nubmer of countries for which patent protection is sought for a single invention. The number of international families in this table is not the same as in appendix table 6-22 because this table includes all robot families with basic patents published in 1981 through mid-1993.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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within Europe; however, this influence is probably not yet revealed fully in these data.[52]

Genetic Engineering

As robot technology is closely identified with advanced manufacturing, genetic engineering is closely identified with the broad field of biotechnology. For this study, genetic engineering is defined as RDNA technology—or more specifically, as the formation of microbial mutants by RDNA techniques. It covers processes for isolation, preparation, and purification of DNA or RNA, DNA or RNA fragments and modified forms thereof; the introduction of foreign genetic material using vectors; vectors; use of hosts; and expression. As used here, genetic engineering excludes monoclonal antibody technology.[53]

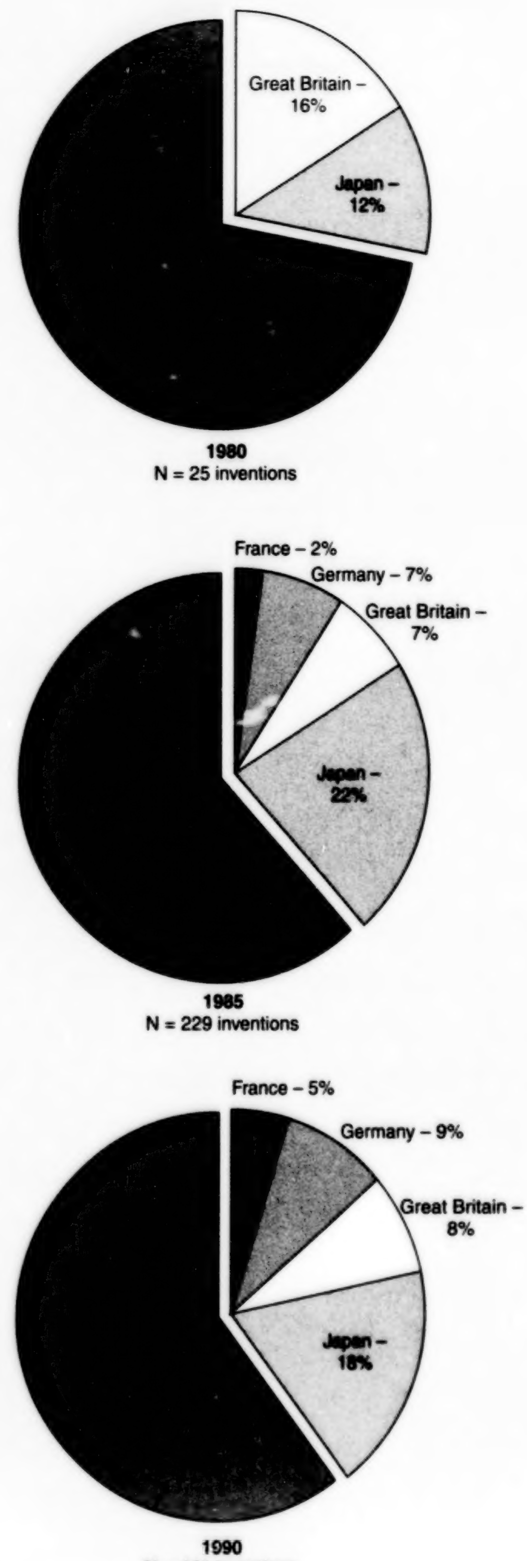
International Patenting Activity. The decade of the 1980s really marks the introduction of genetically engineered products to the global marketplace. From 1980 to 1985, the number of international patent families in this field increased tenfold; it had doubled again by 1989. (See appendix table 6-24.) All of the seven countries with significant technological activity generally followed this trend.

The United States is widely considered the global leader in the field of biotechnology, and these data support that perception. The United States is the priority country (i.e., the location of first patent application) for 57 percent of the internationally patented inventions created during the 1980-90 period. Japan follows with 20 percent, the United Kingdom with 9 percent, and West Germany with 8 percent. (See figure 6-24.)

When the total number of foreign applications associated with each country's genetic engineering technology is considered, the United States continues to lead all other countries in international patenting in this field. The United States had more foreign patents than the other six countries combined, accounting for nearly 60 percent of the 27,000 foreign patents. Comparing the 1986-90 period to the 1981-85 period, it appears that several other countries are gaining on the United States. The United States led in both halves of the decade, followed by Japan, but both countries' leads declined as West German, British, and French foreign patenting shares in this field grew comparatively more rapidly. (See text table 6-7.)

Highly Cited Inventions. The United States, with 50 percent of the total patent families recorded during the 1981-85 period, had the largest proportion of highly cited

Figure 6-24.
Genetic engineering: Share of international patent families, by priority year and country



NOTES: An international patent family is created when patent protection is sought outside of the patenting country. German data are for the former West Germany only.

See appendix table 6-24. *Science & Engineering Indicators – 1993*

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[52] Since patent applications may take up to 18 months before publication, patenting activity data for the years after 1990 are available but incomplete.

[53] The trends discussed for genetic engineering technology are based on the population of 4,385 genetic engineering patent records in the World Patents Index Latest database, with priority applications in the seven countries under study and basic patent publications from 1981 to early 1993. These seven countries accounted for about 85.4 percent of total genetic engineering patent families.

Text table 6–7.
Genetic engineering: Total number of foreign patents, by priority country

Priority Country	1981–85 Number of foreign patents	1981–85 Country share of total	1986–90 Number of foreign patents	1986–90 Country share of total	1981–90 Number of foreign patents	1981–90 Country share of total
Total	7,968	100.0	19,463	100.0	27,431	100.0
United States	5,181	65.0	11,159	57.3	16,340	59.6
Japan	1,344	16.9	2,885	14.8	4,229	15.4
West Germany	599	7.5	2,268	11.7	2,867	10.5
United Kingdom	673	8.4	2,063	10.6	2,736	10.0
France	155	1.9	1,026	5.3	1,181	4.3
South Korea	0	0.0	44	0.2	44	0.2
East Germany	16	0.2	18	0.1	34	0.1

NOTE: Patent population is estimated.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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patent families—73 percent, or 8 of the 11 such families identified.[54] (See text table 6-8 and appendix table 6-25.) With 36 percent of the total families, Japan had just 2 (18 percent) that were highly cited. Great Britain was the only other country with any patent families considered highly cited—1; it had fewer than 6 percent of the total patent families in this field.

In the 1986-90 time period, both the number of new genetic engineering inventions (patent families) and the number of technically important patent families were nearly three times that recorded during the earlier period. Japan (with 1,317 families) moved ahead of the United States (with 1,125) in terms of total number of patent families; however, the United States continues to produce the most highly cited patent families in this technology field. In fact, the United States accounted for 23 of the 35 highly cited patent families filed during the later period, and had 1.8 times as many highly cited patent families as expected based on its level of activity. Great Britain, with far fewer patent families than either Japan or the United States, produced 2.3 times the number of highly cited patent families as expected based on its level of activity.

Despite the large jump in new genetic engineering technologies originating in Japan, the United States appears to lead the other countries in terms of the technological merit of the work being done, based on this indicator. Work done in Great Britain has not produced the same number of patented inventions as in Japan or the United States, but this work does appear to represent important advancements.

Mean International Patent Family Size. Patented genetic engineering inventions developed in Western Europe and the United States appear to be the most commercially valuable based upon this measure. This indicator identified patented inventions originating in West Germany as having the highest commercial potential based on comparison of the mean size of international patent families for this technology. (See text table 6-9.) West German international patents have,

Text table 6–8.
Genetic engineering: Citation index

Priority country	Citation ratio 1981–85	Citation ratio 1986–90
Great Britain	1.7	2.3
United States	1.4	1.8
France	0.0	2.5
Japan	0.5	0.4
West Germany	0.0	0.0
East Germany	0.0	0.0
South Korea	0.0	0.0

NOTE: The citation index is derived from the priority country's share of highly cited patent families divided by its share of total patent families.

See appendix table 6–25. *Science & Engineering Indicators – 1993*

Text table 6–9.
Genetic engineering: Number of international patent families and average family size

Priority country	Number of families	Average family size
West Germany	209	15.5
France	103	13.1
Great Britain	251	12.8
United States	1,492	12.0
Japan	526	9.4
South Korea	6	8.2
East Germany	6	6.7

NOTE: Patent family size is determined by the nubmer of countries for which patent protection is sought for a single invention. The number of international families in this table is not the same as in appendix table 6-22 because this table includes all robot families with basic patents published in 1981 through mid-1993.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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on average, sought patent protection in 15 countries; French and British origin international patents have sought patent protection in 13 countries. Patented genetic engineering inventions originating in the United States rank fourth in perceived commercial exploitation potential. Inventions originating in Japan, South Korea, and East Germany trailed the United States based on this measure.

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[54] Operationally, this included all families with priority application dates from 1981 to 1985 with 12 or more citations, and those with priority application dates from 1986 to 1990 with 6 or more citations.

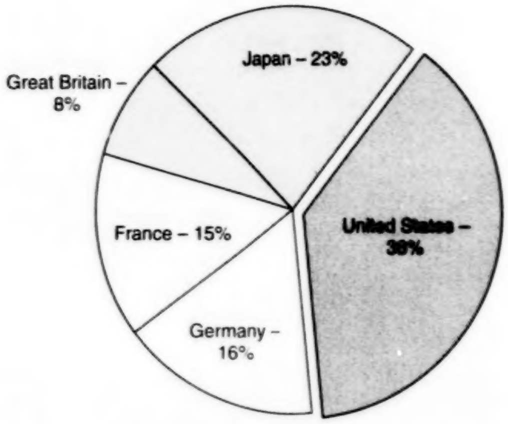
Optical Fibers

National technological positions in the broad and amorphous field of information technology have here been assessed through an examination of international patenting activity of optical fiber technology. Optical fibers are flexible, transparent fibers, usually made of extremely pure glass, and designed and manufactured to guide rays of light. Optical fibers have a greater information-carrying capacity than copper wire: communications companies—anticipating future information demands—are increasingly replacing their copper wire transmission lines with new lines made of optical fiber. For this study, optical fibers were defined to include plastic fibers, optical fiber bundles, optical preforms, and integrated optical waveguides. The definition excludes optical fiber cables and connectors, light sources and receivers, couplers, amplifiers, repeaters, and switches. The seven countries analyzed account for approximately 94.6 percent of total patent activity by all countries in this technology.[55]

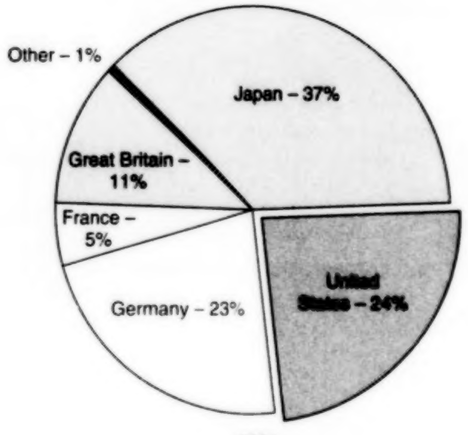
International Patenting Activity. During the 1980-90 period, the seven countries analyzed generated a total of 1,872 international patent families in the field of optical fibers. The formation of international patent families increased nearly every year during the 1980s (there was a slight decrease in number in 1989 compared to 1988), reaching a period high of 261 international patent families formed in 1990.[56]

Japan and the United States led all other nations in the formation of international patent families involving optical fiber technology. Japan surpassed the United States in 1981 and led the seven-nation group thereafter. (See appendix table 6-26.) Japan held 36 percent of the total (with 684 international families) families formed over the period studied; the United States held 30 percent (559 international families). West Germany, Great Britain, and France trailed with 17, 9, and 7 percent of the total, respectively. East Germany and South Korea had comparatively

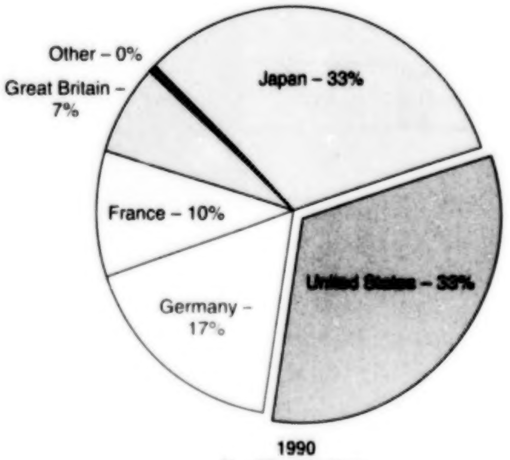
Figure 6-25.
Optical fiber technology: Share of international patent families, by priority year and country



1980
N = 61 inventions



1985
N = 135 inventions



1990
N = 261 inventions

NOTES: An international patent family is created when patent protection is sought outside of the patenting country. German data are for the former West Germany only.

See appendix table 6-26. *Science & Engineering Indicators – 1993*

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[55] The trends discussed for optical fiber technology are estimates based on a sample of 4,930 patent records drawn from the population of 7,848 optical fiber patent records in the World Patents Index Latest database with priority applications in the seven countries under study and basic patent publications from 1981 to early 1993. The 4,930 patent records include the entire population of optical fiber patent families with priority applications in the United States, West Germany, East Germany, Great Britain, France, and South Korea; and a 43-percent sample of the patent families with a priority application in Japan. Therefore, data presented for Japan are estimates, while data presented for the other six countries are true population figures.

[56] 1990 is the last year for which complete data are available.

Text table 6–10.
Optical fiber technology: Total number of foreign patents, by priority country

Priority Country	1981–85 Number of foreign patents	1981–85 Country share of total	1986–90 Number of foreign patents	1986–90 Country share of total	1981–90 Number of foreign patents	1981–90 Country share of total
Total	4,063	100.1	7,527	100.0	11,590	99.9
United States	1,457	35.9	2,555	33.9	4,012	34.6
Japan	1,228	30.2	1,796	23.9	3,024	26.1
West Germany	673	16.6	1,485	19.7	2,158	18.6
United Kingdom	454	11.2	1,023	13.6	1,477	12.7
France	230	5.7	654	8.7	884	7.6
South Korea	20	0.5	5	0.1	25	0.2
East Germany	1	0.0	9	0.1	10	0.1

NOTE: Patent population estimated.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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insignificant numbers of international patent families in this technology. (See figure 6-25.)

When the total number of foreign applications associated with each country's optical fiber technology is considered, the United States and Japan switch places, and the United States becomes the leader in terms of total numbers of foreign patents sought for optical fiber technology. Out of a total of 4,063 optical fiber foreign patents generated from priority applications filed by the seven countries under study during the 1981-85 period, the United States generated 36 percent (1,457 patents) of the total, and Japan generated 30 percent (1,228 patents). In the second half of the decade, the United States improved on its lead over Japan. However, the Western European nations showed the greatest growth in foreign patenting, gaining on both the United States and Japan. (See text table 6-10.)

Highly Cited Inventions. During the 1981-85 period, the seven countries together created 2,043 optical fiber patent families, of which 22 were highly cited.[57] Japan generated the greatest number of patent families in this technology area during this period and also had the greatest number of highly cited inventions—12 (or 54 percent of all highly cited patent families). Yet, when each country's number of highly cited patent families is normalized by calculating its citation ratio, the United States leads all seven nations. The United States had a citation ratio of 2.0, or two times as many highly cited patent families than would be expected given its share of total families during this period. Japan's citation ratio, 0.9, suggests that the 12 highly cited families produced by Japan during this period were slightly below expectations, given the total number of patent families generated by Japan. Great Britain had only one highly cited family, but meets expectations in this indicator with a citation ratio of 1.0. (See text table 6-11 and appendix table 6-27.)

In the 1986-90 time period, the number of optical fiber inventions (patent families) doubled, and the number of technically important patent families were over three times that recorded during the earlier period. Japan accounted for nearly 69 percent of the patent families generated in this period, but again did not produce the expected number of highly cited families out of this total. It ended up with a citation ratio of only 0.5. With a citation ratio of 2.6, the United States once again shows high productivity of technically important optical fiber inventions.

Several European countries showed greater productivity of technically important optical fiber inventions in the late 1980s. Great Britain stands out in this later period, with a citation ratio of 3.5, the highest among the seven countries. France, with a citation ratio of 2.9 during this period, also greatly exceeds expectations, producing nearly three times the number of highly cited families expected from its total number of optical fiber inventions patented during this period.

Text table 6–11.
Optical fiber technology: Citation index

Priority country	Citation ratio 1981–85	Citation ratio 1986–90
United States	2.1	2.6
Japan	0.8	0.5
Great Britain	1.0	3.5
France	0.0	2.9
West Germany	0.5	1.1
East Germany	0.0	0.0
South Korea	0.0	0.0

NOTE: The citation index is derived from the priority country's share of highly cited patent families divided by its share of total patent families.

See appendix table 6–27. *Science & Engineering Indicators – 1993*

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[57] Operationally, these included all families with priority application dates from 1981 to 1985 with eight or more citations, and those with priority application dates from 1986 to 1990 with three or more citations.

Text table 6–12.
Optical fiber technology: Number of international patent families and average family size

Priority country	Number of families	Average family size
Great Britain	174	10.0
United States	634	8.0
France	154	7.9
West Germany	351	7.8
Japan	734	5.2
South Korea	6	4.8
East Germany	10	2.0

NOTE: Patent family size is determined by the nubmer of countries for which patent protection is sought for a single invention. The number of international families in this table is not the same as in appendix table 6-26 because this table includes all optical fiber families with basic patents published in 1981 through mid-1993.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

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Mean International Patent Family Size. Based on mean international family size, the optical fiber inventions with the highest perceived foreign market potential were produced in Great Britain. Patent protection for these British-origin optical fiber inventions has been sought in, on average, 10 foreign countries. This compares to an average international patent family size of about eight countries for the United States, France, and West Germany (8.0, 7.9, and 7.8 countries on average, respectively).

Optical fiber inventions developed in Japan for which firms sought patent protection in at least one other country, on average, have an international patent family size of just 5.2 countries. (See text table 6-12.) The optical fiber inventions from South Korea and East Germany had even less perceived potential in foreign markets, with average international family sizes of just 4.8 and 2.0, respectively.

Small Business and High Technology

Many of the new technologies and industries seen as critical to the Nation's future economic growth are closely identified with small business. For example, biotechnology and computer software are industries built around new technologies that were largely commercialized by small business.[58] Small business retains certain advantages over large businesses in commercial environments characterized by fast-moving technologies and rapidly changing consumer needs. A keen receptivity to new product ideas found outside their own operations characterizes this efficiency (see Hanson 1991). Small businesses supplement internal product development with new product ideas drawn from dealings with customers, suppliers, government labs, universities, and others to ensure useful innovations. These attributes make small business a key sector to watch as the Nation seeks to stimulate the development, adoption, and diffusion of new technologies.[59]

This section presents information on new company formation in the United States and foreign ownership of new high-tech companies.[60] The discussion focuses on companies active in the following eight technology fields:

- automation,
- biotechnology,
- computer hardware,
- advanced materials,
- photonics and optics,
- software,
- electronic components, and
- telecommunications.

These fields encompass many of the technologies considered critical to the country's future economic competitiveness (National Critical Technologies Panel 1993).

Trends in New U.S. High-Tech Business Startups

The rapid formation of new high-tech companies observed during the second half of the 1970s and the early 1980s was followed by a sharp decline in such formations in the late eighties. (See appendix table 6-28.) That declining trend appears to be continuing into the early 1990s with the number of annual company formations averaging only about one-third of that seen in the slower second half of the 1980s. Still, nearly half of all U.S. high-tech companies operating in 1993 were formed in just the last 14 years. That proportion is even higher (around 60 percent) for computer-related companies and for companies whose main business involves biotechnology.

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[58] The role of small business as a commercializer of new technologies is somewhat unique to the United States. See Mowery and Rosenberg (1993).

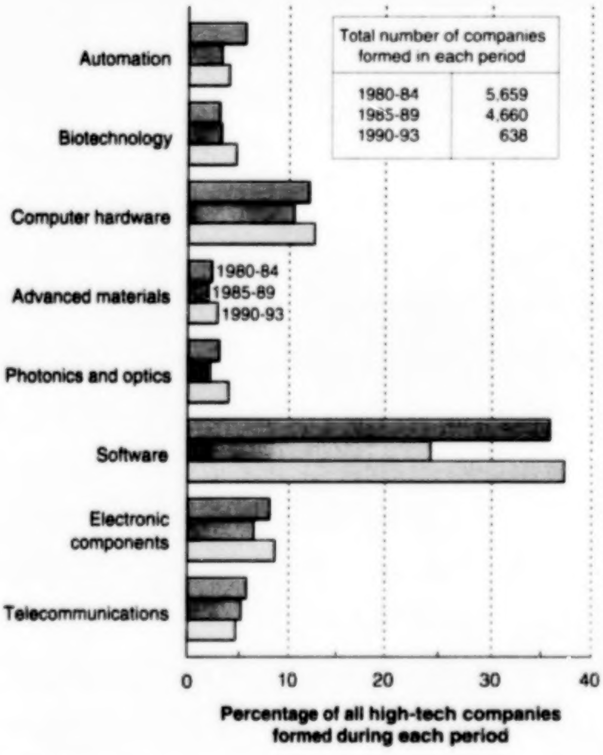
[59] In a 1982 study done for the Small Business Administration comparing innovation between small and large firms, it was found that small firms produced 2.4 times as many innovations per employee as did large firms. See Futures Group (1984) and Hanson, Stein, and Moore (1984).

[60] Information in this section is derived from the CorpTech database, owned by Corporate Technology Information Services, Inc. The CorpTech database permits an inspection of small business entities by technology field. This database includes many of the new startups and private companies often missed by other databases and is one of the most current sources of information on small newly formed companies active in high-tech fields. The database attempts to be all-inclusive: by CorpTech's own estimate, it includes 99 percent of large companies (over 1,000 employees), 75 percent of medium-sized companies with 250 to 1,000 employees, and 65 percent of companies with less than 250 employees. When prospective companies for inclusion in the database are identified, they are sent questionnaires covering their size; status (private or public, independent, subsidiary, or joint venture); year formed; and product groups in which they are active. The version of the database used here (Rev. 8.2 1993) includes about 35,000 independently managed companies.

Technologically, the 1980s mark the decade of the computer and its rapid integration into America's daily life. By the mid-eighties, it was hard to find a modern office that did not use a personal computer (PC), a new car that did not include computerized functions, or a child that did not have access to a PC in elementary school. The trends in new company formations among the various fields of technology reflect this revolution. For example, about half of the new high-tech businesses formed since 1980 were computer-related companies. Among these, software companies accounted for the largest number.

The number of new software companies stands out not just in the computer-related category but also when compared to all other technology fields. According to the CorpTech database, software development and/or servicing is the primary business for 34 percent of the 10,000 new high-tech companies formed since 1980 and in existence in 1993. However, the large number of new software companies started in the early 1980s (1980-84) was not duplicated in the second half of the decade, with the number of new software startups dropping nearly 45 percent. Thus far in the 1990s, software technology continues to create the greatest number of small business startups among the eight technology fields examined, but not at the pace set during the previous decade. (See figure 6-26.)

Figure 6-26.
High-tech business formation, by technology



NOTE: Data reflect information collected through July 1993.

See appendix table 6-28. *Science & Engineering Indicators – 1993*

Other technology fields that exhibited relative share growth in the early 1990s are companies in the biotechnology, advanced materials, and photonics and optics fields. Biotechnology was the only technology field that exhibited produced steady relative share growth during the 1980s and into the early 1990s.

Foreign Ownership of U.S. High-Tech Companies

Fewer than 7 percent of the 23,000 new high-tech companies listed in the CorpTech database were under foreign ownership in 1993. (See appendix table 6-29.) The United Kingdom has the largest U.S. presence, followed by Japan and Germany. Although these three countries own companies active in each of the eight technology fields examined, they each tend to be drawn to certain fields. The United Kingdom and Germany tend to own U.S. companies involved in the development of advanced materials, and Japan tends to own telecommunications and computer hardware companies.

Compared with the major industrialized countries, Taiwan and South Korea own relatively few U.S. high-tech companies. Taiwan's acquisitions are in two fields—computer hardware and telecommunications. South Korea also owns companies in these fields, but its largest concentration of acquisitions are in the biotechnology field.

New High-Tech Competitors[61]

The previous sections identified several nations that have made tremendous technological leaps forward over the past decade. Whether these countries will play even more important roles in technology development in the near future remains to be seen, but several Asian economies appear to be well-positioned for just such roles. Their large and continuing investments in science and engineering education and R&D resources and infrastructure provide a foundation on which to build their position in many high-tech areas.[62]

This section attempts to assess the future national competitiveness in high-tech industries of eight Asian economies: the four newly industrialized economies—Hong Kong, Singapore, South Korea, and Taiwan—and

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[61] This section presents early results of research sponsored by the National Science Foundation aimed at developing new indicators of national technological competitiveness. These indicators have undergone extensive validity and reliability testing that supports their use as a tool for both policy analysis and research. See Roessner, Porter, and Xu (1992). The present discussion focuses on several Asian economies whose rapid growth or potential to make important contributions in S&T areas has attracted the attention of the industrialized world. Data assessing the high-tech potential of countries in other important regions are being collected in order to provide more comprehensive assessments of technological competitiveness in future *Science & Engineering Indicators* reports.

[62] See chapter 2, "Asian Students in U.S. Universities," and SRS (1993).

Leading Indicators of National Competitiveness

The model used to develop the competitiveness projections discussed in this section combines various quantitative data with expert-derived measures to produce the following four leading indicator areas.

- *National commitment:* evidence that a nation is taking directed action to achieve technological competitiveness.
- *Socioeconomic infrastructure:* the social and economic institutions that support and maintain the physical, human, organizational, and economic resources essential to the functioning of a modern, technology-based industrial nation.
- *Technological infrastructure:* the social and economic institutions that contribute directly to a nation's capacity to develop, produce, and market new technology.
- *Productive capacity:* the physical and human resources devoted to manufacturing products, and the efficiency with which those resources are used.

These indicators have been the subject of several research projects conducted in three phases over 5 years. Phase I sought to identify a set of composite indicators that could be used to assess current and future national competitiveness in technology-based product markets; phase II focused on expanding country coverage and testing the indicators; and phase III, now under way, entails further model refinement and testing. For further details on this research and on indicator construction, see Porter and Roessner (1991).

four countries viewed as emerging Asian economies (EAEs)—China, India, Indonesia, and Malaysia. This competitiveness is gauged through scores in four leading indicator areas—national commitment, socioeconomic infrastructure, technological infrastructure, and productive capacity.[63] (See figure 6-27.) These indicators were designed to identify those countries with the potential of becoming more important exporters of high-technology products over the next 15 years. A more thorough discussion of the indicators and projection model used in this analysis is provided in "Leading Indicators of National Competitiveness."[64]

National Commitment

The national commitment indicator attempts to identify those nations whose business, government, and cultural orientation encourages high-technology development. This indicator was constructed using information from a survey of international experts[65] and published data. The survey asked the experts to rate national strategies that promote high-tech development, social influences favoring technological change, and entrepreneurial spirit. The published data were used to rate each nation's risk factor for foreign investment over the next 5 years (Frost and Sullivan 1987 and 1989).

The four Asian NIEs received very close ratings on this indicator. (See figure 6-27.) However, experts' higher ratings for Hong Kong's cultural and social attitudes about new technology and its strong entrepreneurial spirit elevated that economy's composite score over the other NIEs. (See appendix table 6-30.)

Three of the four emerging Asian economies (China, India, Indonesia) scored quite low relative to other nations on this indicator. Their scores were brought down by experts' comparatively low judgments of their cultural and social attitudes toward new technology and entrepreneurship. China had the lowest overall score of the three, a result of being judged to have the highest investment risk and the lowest predisposition for innovative action and risk-taking.

According to this indicator, Malaysia leads the other EAEs in its national commitment toward achieving technological competitiveness. Malaysia's scores were consistently and significantly higher than those of the other EAEs across the full range of variables considered for this indicator. Nevertheless, Malaysia's scores were still well below those for the more advanced Asian NIEs.

Socioeconomic Infrastructure

This indicator assesses the underlying physical, financial, and human resources needed to support high-tech

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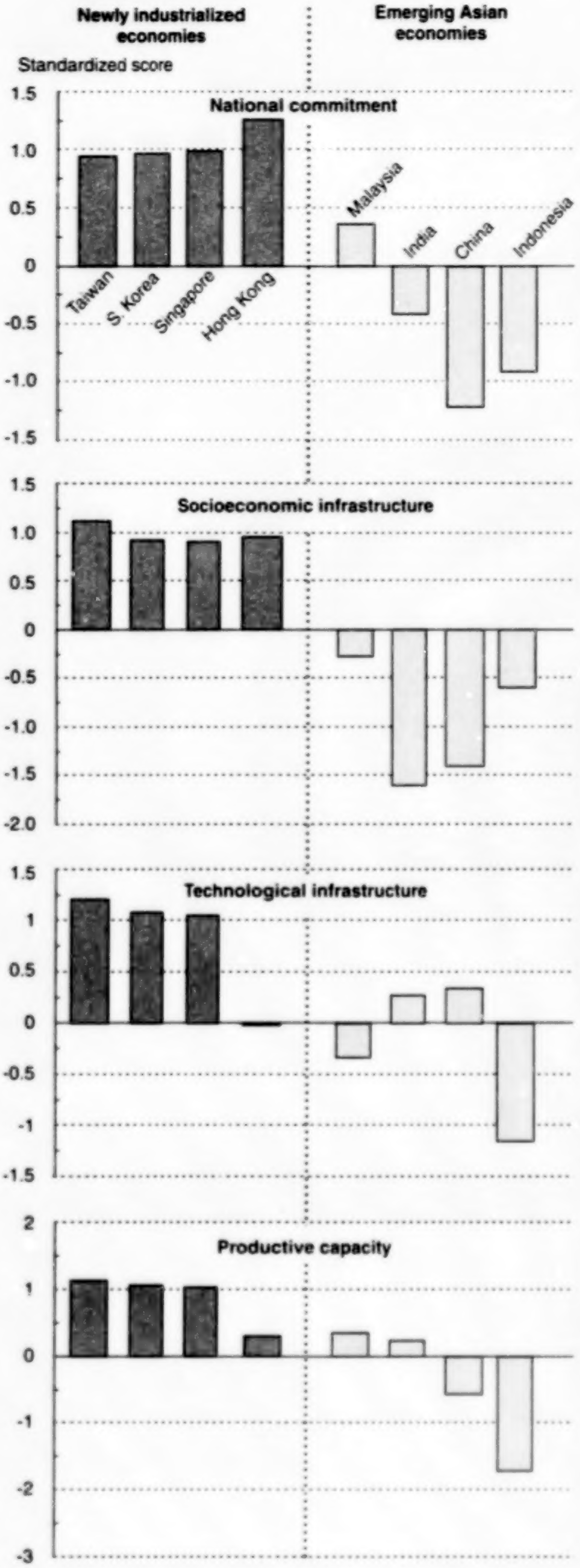
[63] These four indicators were used by OTA (1992) to examine Mexico's technological capacity.

[64] The scores discussed in this section are extracted from Roessner (1992). This report calculated standard scores based on data for 10 economies: China, Hong Kong, India, Indonesia, Malaysia, the Philippines, Singapore, South Korea, Taiwan, and Thailand. "The survey instrument consisted of 15 closed-ended questions with responses on a five-point scale. The instrument was sent to a sample of country experts in April 1990. Experts were selected because of their knowledge of the technology policies and socioeconomic conditions in [the] countries studied.... Occasional high variance in responses to individual survey items were atrributable to rater inconsistencies rather than to inherent uncertainty about a nation's status. Generally, the survey items discriminated well among countries, and the median standard deviation of responses to individual questions within countries was less than one on a five-point scale."

[65] The survey instrument consisted of 15 closed-ended questions with responses on a 1-point scale. The instrument was sent to a sample of country experts in April 1990; these experts were selected based on their knowledge of the technology policies and socioeconomic conditions in the countries studied. Occasional high variance in responses to individual survey items were attributable to rater inconsistencies rather than to inherent uncertainty about a nation's status. Generally, the survey items discriminated well among countries, and the median standard deviation of responses to individual questions within countries was less than 1 on the 5-point scale (Roessner, Porter, and Xu 1992).

Figure 6-27.
Leading indicators of technological competitiveness for selected Asian economies



NOTE: Scores were normalized to median values of zero for the 10 economies (the 8 noted here and the Philippines and Thailand), based on surveys of expert opinion conducted in 1990 and statistical data for the late 1980s.

See appendix table 6-30. *Science & Engineering Indicators – 1993*

development. It was built from published data on percentages of population in secondary school and higher education[66] and survey data evaluating the mobility of capital and the extent to which foreign businesses are encouraged to invest and/or do business in each country.

The data again show a clear separation between the NIEs and EAEs. (See figure 6-27.) Although NIE scores for this leading indicator are tightly bunched, Taiwan received the highest score on the basis of its strong track record for general education. Hong Kong scored high on those variables comparing mobility of capital and encouragement of foreign investment.

Among the EAEs, Malaysia was rated highest, based on the underlying physical, financial, and human resources it has to support technology development. Malaysia's score was bolstered by a stronger showing in both published education data and the experts' opinions of Malaysia's physical and financial resources. India had the lowest overall score; it was held back by a poor rating on the variable comparing the encouragement of foreign business and investment.

Technological Infrastructure

Four variables are used to develop this indicator which evaluates (1) a nation's potential to expand its scientific and technological knowledge and (2) the industrial focus of its R&D enterprise. This indicator was constructed using published data on the number of scientists in R&D (United Nations data); national purchases of electronic data processing equipment (Elsevier Advanced Technology); and survey data that asked experts to rate the economy's output of indigenous academic science and engineering, the ability to make effective use of technical knowledge, and the linkages of R&D to industry.

Taiwan received the highest composite score of the eight Asian economies (both NIEs and EAEs), with strong ratings for each of the variables. (See figure 6-27.) The lowest score among the NIEs was accorded to Hong Kong. This is not surprising, considering its traditional reliance on entrepreneurial expertise rather than on formally conducted R&D. In addition, its comparatively smaller population may have played some part in its low score since numbers of trained scientists and engineers and the size of the attendant R&D enterprise are compared with countries with much larger populations in the region.[67] However, even though Singapore's population is smaller than Hong Kong's, Singapore's extensive national investments in information technology and its prominence in the region as a computer manufacturer more than compensated for any population bias and lifted its score above that for Hong Kong.

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[66] The Harbison-Myers Index (which measures the percentage of population attaining secondary and higher educations) was used for these assessments.

[67] This assessment of Hong Kong may change in the near future spurred on by the change in rule from Britain to the China in 1997. Hong Kong has recently opened a new University of Science & Technology and an Industrial Technology Center. (See Business Week 1992.)

Among the EAEs, China and India have the highest rated technological infrastructures. China scored well on each of the variables, but distanced itself from the other EAEs by virtue of its comparatively large purchases of computer equipment. India's relatively high score rested on the strength of its large number of trained scientists and engineers and their many contributions to the S&T knowledge base. On the other hand, Indonesia's large population did not save it from the bottom ranking with low scores on each of the variables that make up this indicator.

Productive Capacity

This indicator evaluates the strength of a nation's current, in-place manufacturing infrastructure as a baseline for assessing its capacity for future growth in high-tech activities. It factors in expert opinion on the availability of skilled labor, numbers of indigenous high-tech companies, and judgments on the management capabilities in the country, combined with published data on current electronics production in each country.

Taiwan's productive capacity scored the highest among the NIEs, although South Korea and Singapore were not far behind. (See figure 6-27.) Hong Kong fell short compared to the other NIEs, with low expert opinions of its availability of skilled labor and on the variable measuring electronics manufacturing.

Malaysia once again stood out among the EAEs—in fact, its score was closer to that of the NIEs than to the group of emerging Asian economies. India's score was also quite high compared to the other countries in this group, supported by its comparatively large electronics manufacturing industry and its tradition of training its students in science and engineering.

Summary: Assessment of Future Competitiveness[68]

Based on various indicators of technological competitiveness, including those discussed in this section,[69] several Asian economies seem headed toward future prominence in technology development—a prominence likely to lead to a greater presence in high-tech product markets.

Taiwan and South Korea seem best positioned to increase their competitiveness in technology-related fields and markets and move closer to Japan in terms of technological stature. Strong patent activity in electronics and telecommunications, tapping into U.S. technological know-how, and incorporating advanced technology products throughout their economies are a few of the indicators suggesting technological advancement for these economies. The set of leading indicators highlight the technological infrastructure and productive capacity in both economies that should support further growth in their high-technology industries.

Singapore and Hong Kong, while showing many signs of technological strength, seem to be operating on a somewhat narrower technology foundation than are Taiwan and South Korea. They have not shown the same level of patent activity or the same presence in global technology markets as have the other two NIEs. Hong Kong is the region's wild card, however. Integration with China is scheduled for 1997 and whether the Hong Kong industrial and technological base will continue to grow will depend upon how it is incorporated in the new China.

Malaysia is the single emerging Asian economy that, on the basis of these indicators, could likely develop into the next Asian "tiger"—that is, an NIE. Malaysia is purchasing increasing amounts of advanced technology products and has attracted large amounts of foreign investment to establish its own in-country high-tech manufacturing facilities. Even if these facilities are mostly platform (assembly) operations today, Malaysia's strong national commitment, socioeconomic structure, and productive capacity suggest that as it gains technological capabilities, more complex processing will likely follow.

India shows tremendous strengths in certain of the indicators, but also shows tremendous weakness. The country has a long tradition of educating highly qualified scientists and engineers and a well-deserved reputation for excellence in basic research, yet it harbors one of the highest illiteracy rates in the region. This anomaly produced the lowest score given among the eight economies for the socioeconomic infrastructure indicator. Uneven acceptance of foreign products and investment has inhibited internal competition that otherwise may have motivated India to better capitalize on its engineering strengths. Some of the regulations and policies related to foreign investment are slated to change in the near future, and this may improve India's position over the long run (*The Economist* 1991).

China and Indonesia show many mixed signs in these indicators of technology development and competitiveness. Both countries show rising purchases of U.S. advanced technology products and increased licensing of technological know-how. Yet compared with the other Asian economies, these countries do not show the same level of national commitment, technological infrastructure, and productive capacity that would project technological competitiveness in the near future.

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[68] For further analysis of future competitiveness of these eight economies, see "Results of Preliminary Analysis."

[69] While the conclusions drawn from the leading indicators should be considered preliminary, they are consistent with trends presented in SRS (1993) and SRS (forthcoming).

Preliminary Analysis of New Data

A preliminary analysis of new quantitative and expert-derived data indicates a further narrowing between the group of NIEs (Hong Kong, Singapore, South Korea, and Taiwan) and the group of EAEs (China, India, Indonesia, and Malaysia). The new set of data show surprising strength by ***Singapore*** compared to the other newly industrialized economies, improving its scores in three of the four leading indicators. Yet other indicators suggest that Singapore's high-tech strength is narrow compared to that of ***Taiwan*** and ***South Korea***. New data for ***China*** show a marked improvement in each of the four indicators. Memories of Tianenmen Square linger, but China's national potential and commitment to achieving market-driven economic growth continue to elevate that country's prospects as a future high-tech competitor. Efforts by ***India*** to encourage more foreign investment appear to be paying off, as suggested by the sizeable improvement in the indicator measuring its socioeconomic infrastructure. Nevertheless, ***Malaysia*** continues to be the standout among the EAEs.

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Chapter 7
Science and Technology: Public Attitudes and Public Understanding

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Highlights

INTEREST IN AND INFORMATION ABOUT S&T

- **The level of interest in science and technology (S&T) has remained fairly stable over the past 14 years.** Approximately 40 percent of Americans reported that they were very interested in scientific and technological issues. Compared to citizens in Japan and the European Community, more Americans expressed a high level of interest in new medical discoveries.

- **Only about 10 percent of American adults think of themselves as being very well-informed about science and technology.** Only 12 percent of Americans thought that they were "very well-informed" about issues involving new scientific discoveries, and only 10 percent claimed to be "very well-informed" about issues concerning the use of new inventions and technologies.

- **Most Americans depend on television and newspapers as their primary source of news and information.** When looking for more specialized information, e.g., personal health information, a third of American adults continue to rely on television.

ATTITUDES TOWARD S&T

- **Americans continue to hold science and medicine in high regard.** Over the last 20 years, the proportions of American adults who report "a great deal of confidence" in the leadership of the scientific community and the leadership of medicine have been among the highest for any institutions in the United States, including the Supreme Court.

- **Approximately 80 percent of Americans believe that S&T have increased our standard of living, enhanced working conditions, and improved public health.** Throughout the last decade, at least 70 percent of Americans have continued to express the view that the benefits of scientific research have exceeded any risks or harms associated with that work.

- **Many Americans hold mixed views about the motives and behavior of individual scientists.** Eighty percent of Americans think scientists want to work on things that will make life better for the average person, but 53 percent accept the idea that "many scientists make up or falsify research results to advance their careers or make money."

PUBLIC UNDERSTANDING OF SCIENCE

- **The public understanding of basic environmental concepts is uneven, with high levels of understanding of some ideas and very little understanding of others.** Over 60 percent of American adults understand that the thinning of the ozone layer can lead to increased risk of skin cancer and that acid rain can damage forests, but fewer than 1 in 10 know the location of the primary hole in the ozone layer or can provide a scientific explanation of acid rain. A large proportion of the public tends to think that all forms of pollution, including auto exhausts, contribute to every major environmental problem. Relatively few citizens demonstrate the ability to relate specific sources of pollution to particular kinds of environmental damage.

- **A higher proportion of European adults than U.S. adults classify themselves as having a clear understanding of several important environmental concepts.** For example, 44 percent of Europeans say they have a clear understanding of the hole in the ozone layer, compared to 30 percent of Americans.

YOUTH UNDERSTANDING AND ATTITUDES

- **Most high school seniors (52 percent) were uncertain about the potential impact of computers and automation on jobs,** and the balance was about evenly divided between optimists and pessimists. The majority (55 percent) of U.S. adults surveyed on this issue in 1992 expected computers and automation to eliminate more jobs than they would create.

- **Among recent high school graduates who have developed any attitude or opinion toward science and technology, there is evidence of generally positive attitudes toward organized science.** A substantial proportion of 1990 and 1993 high school graduates indicated that they had not developed an attitude toward, or were unsure about, a wide range of science and technology issues.

Introduction

Chapter Background

Most Americans today grew up with satellites circling the planet, the ability to pick up a telephone and call directly to almost anywhere in the world, and the expectation that modern medicine can cure or control most conditions. Future generations of Americans will undoubtedly live in an increasingly scientific and technological society.

In light of this circumstance, it is important to understand the American view of science and technology (S&T). Do Americans recognize S&T's contributions to their present standard of living? What do they think will be the future relationship between science, technology, and economic prosperity? How do they assess the impact of S&T on their lives and well-being? How many Americans have a sufficient understanding of S&T to participate meaningfully in public policy debates involving scientific and technological issues? And finally, how do Americans' views compare to those of Europeans and the Japanese? Answers to these and related questions can be gained, in part, by studying the level of interest that Americans have in scientific and technical issues, how much they know about those issues, and how closely they follow them.

The pace of scientific and technological change increases rapidly; consequently, the study of science and mathematics in school is merely preparation for a lifetime of learning about new developments. Contemporary adults try to keep pace with these changes primarily through major media sources, trusting—at some level—that the information provided is accurate. Identification of information sources and determination of their perceived reliability provides additional indications of Americans' ability to prepare for the future.

Finally, examining the attitudes of U.S. adults toward S&T, and understanding the emergence of attitudes among the next generation, can provide insights for policymakers as to whether young Americans are turning away from or toward science and technology. This analysis may also help determine if there is growing distrust or growing confidence in science among American youth—a factor that may affect their future policy or career decisions.

Chapter Organization

To explore the issues raised above, data from this and previous *Science & Engineering Indicators* reports are used and—in some areas—combined with survey results from Japan and the European Community. The first section focuses on the level of *interest* in S&T, the public's self-perceived level of *understanding*, and *attentiveness* to S&T issues. Comparative information from the European Community and Japan is also examined. The section also looks at the primary sources of information used by various segments of the public to learn about S&T, and the level of trust they place in those sources.

The second section examines public *attitudes* toward S&T in general and toward specific scientific and technological issues. It looks at patterns of change over the last 15 years relating to organized science, scientists, specific controversies, government spending, and the broad impact of S&T on the quality of life. Comparative responses from citizens in Japan and the European Community are also reviewed.

The third section explores the *level of public understanding* of science and technology. Using a wide array of measures, this section attempts to estimate the proportions of U.S adults who understand selected scientific, technological, biomedical, and environmental terms and concepts. The section also compares U.S. responses to those of the European Community and Japan.

The final section uses data from a continuing longitudinal study of U.S. youth to assess the attitudes of the next generation of Americans toward S&T. Data from national samples of public high school seniors are used to estimate attitudes toward both organized science in general and selected scientific and technological issues in particular.

Interest in and Information About S&T

The public policy agendas of modern industrial democracies are diverse and complex, and few citizens are able to focus on and stay informed about more than a few issue areas. Beginning with the work of Gabriel Almond (1950), social scientists have recognized that citizens of complex modern societies must "specialize" their political interests, following those issue areas about which they feel they know the most or feel are the most important to themselves, their families, their businesses, or the country in general. This section presents study data aimed at identifying public interest in a variety of issue areas; it specifically focuses on the American public's level of interest in, and degree of informedness on, science and technology.

Interest in S&T Issues

U.S. Public. The level of interest in science and technology in the United States has remained fairly stable over the last 14 years.[1] The results of public attitude studies conducted for *Science & Engineering Indicators* in 1992 show that around the same proportion—about 37 percent—of Amercians, have reported that they were

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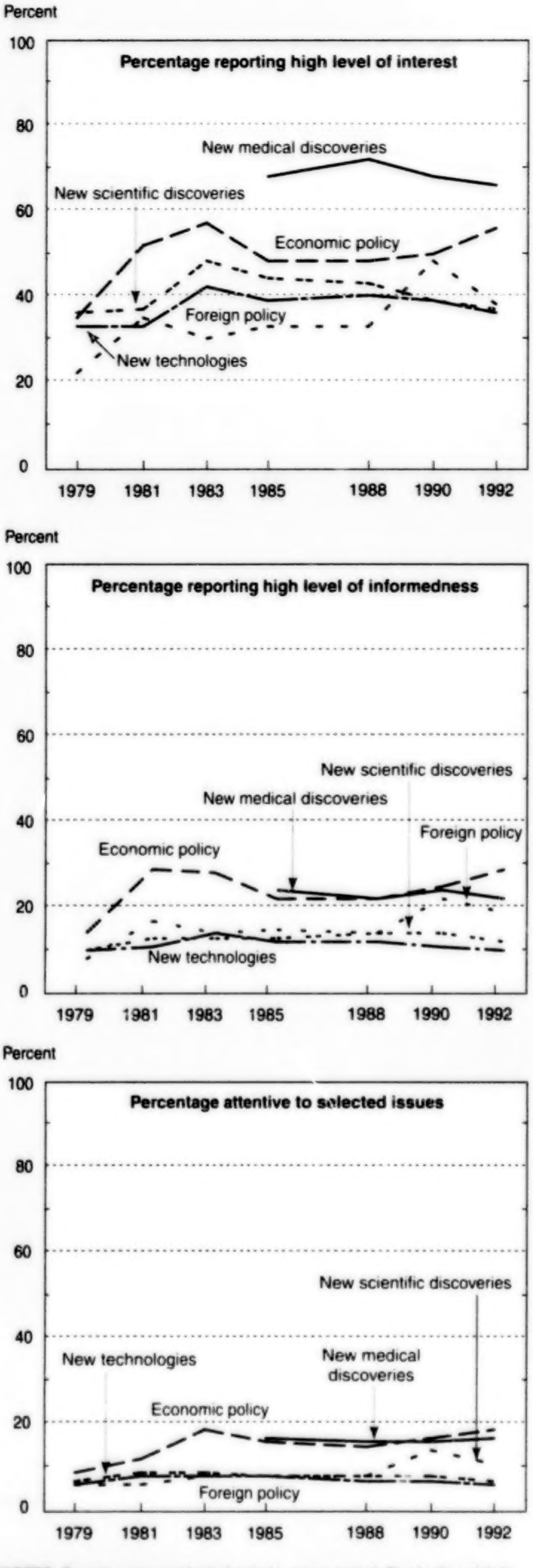
[1] Of the 11 *Indicators* volumes published since 1972, 10 have included a chapter on public attitudes toward and understanding of S&T. The data for the present chapter are drawn from two parallel studies conducted in 1992 and 1993, under the direction of the Chicago Academy of Sciences, and sponsored by the National Science Foundation and the National Institutes of Health. One study continued the core of attitude and knowledge items from previous *Science & Engineering Indicators* studies; it included telephone interviews with a random-digit sample of 2,001 adults. The second study attempted to measure public attitudes toward and understanding of biomedical concepts and technologies. The biomedical study was based on a stratified random-digit sample of 3,111 interviews. See "Primary Data Sources" for details on data access for these two studies.

Figure 7-1.
Public interest and informedness regarding selected issues



NOTES: Survey was conducted only in years noted. For further details on the definition of attentiveness, see appendix table 7-7.

See appendix tables 7-1, 7-4, and 7-7.

Science & Engineering Indicators – 1993

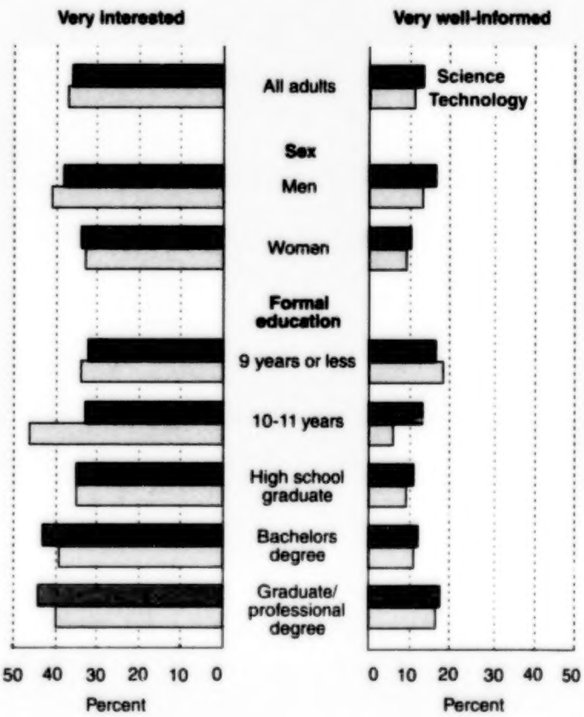
very interested in ***new scientific discoveries*** and ***new inventions and technologies***. (See figure 7-1.)

Beginning in 1985, public attitude studies conducted for *Science & Engineering Indicators* have included questions about interest in ***new medical discoveries***; the results indicate a higher level of interest in those issues than in economic, science, or technology issues. (See figure 7-1.) Approximately two-thirds of American adults have since reported that they are very interested in issues about new medical discoveries, with only 3 percent claiming to have little or no interest. Older adults tend to be significantly more interested in new medical discoveries than younger adults.

Individuals with higher levels of formal education and more high school and college coursework in science and mathematics tend to report higher levels of interest in *new scientific discoveries* than do those with 12 or fewer years of formal education. (See figure 7-2.) In 1992, respondents with a graduate or professional degree reported a high level of interest in new scientific discoveries (44 percent), while adults with 9 years of schooling or under evinced less interest (32 percent). These data indicate a correlation between level of schooling/coursework and degree of interest in these areas. No similar relationship exists with regard to issues on the use of new inventions and technologies.

Interest in *space exploration* was highest among college graduates and lowest among citizens with less formal

Figure 7-2.
Public interest in and informedness on science and technology: 1992



See appendix tables 7-2 and 7-5.

Science & Engineering Indicators – 1993

Five Basic Concepts for Thinking About Public Attitudes and Knowledge

The following concepts are useful in thinking about public attitudes towards and understanding of science and technology in general, and in understanding the specific research methods used in the major studies providing data for this chapter. (These studies are described in "Primary Data Sources.")

- **Opinions***:* Opinions are lightly held dispositions toward a given issue, person, or other attitude object (Hennessy 1972). If asked about some issue that is of little concern to a particular individual, that person might give a response as part of a conversation or interview, but that opinion is not salient to his or her basic interests or values, nor is it likely to be stable over time.

- **Attitudes:** Attitudes are dispositions toward an issue, person, or other attitude object that reflect important concerns and values (Hennessy 1972). A person with a long-standing interest in a given area will have firm feelings about that area. If asked about an issue of major concern to them, most individuals can provide a detailed and logically consistent response, reflecting their previous thinking on that issue and its connections to their other concerns and values. Attitudes, in contrast to opinions, tend to be stable over time and integrated into an individual's broader set of values and concerns.

- **Issue interest:** Issue interest is a relative measure, both conceptually and empirically. In 1992 and previous *Science & Engineering Indicators* studies, individuals have been asked to indicate whether they were "very interested, moderately interested, or not at all interested" in each of a set of public policy issue areas. The use of this trichotomous self-report was first validated in a 1979 study where the level of self-reported interest was highly correlated with the selection of newspaper headlines and stories that individuals indicated they were likely to read (Miller, Prewitt, and Pearson 1980). Although there is no universal metric underlying this set of questions, the distinction between "very interested, moderately interested, and not at all interested" reflects the relative level of interest the responding individual assigns to each issue area. Since the number of issues that an individual can follow effectively is limited, these responses provide an indicator of those areas each individual considers to be of greatest personal interest (Miller 1983a).

- **Objective level of understanding:** As used here, the objective level of understanding is a reflection of the number of selected scientific and technical concepts that were correctly identified by interview in 1992 and earlier studies. This allows the construction of a measure of the level of understanding of S&T held by adults in the United States and other countries. Note, however, that interviews (by telephone or in person) are able to assess a selected range of concepts and generally cannot measure either indepth understanding of concepts or the ability to use and apply these concepts in practical, hands-on settings. Nonetheless, it is useful to be able to distinguish between those citizens who have a minimal level of understanding of various scientific concepts, such as the structure of matter and of the solar system, the dynamics of certain key aspects of the planet on which we live, and basic concepts about the origins and survival of plant and animal life, and those who do not understand those basic constructs.

- **Subjective level of understanding:** Apart from some objective metric of understanding, individuals have a subjective metric that allows them to classify themselves as "very well-informed, moderately well-informed, or not very well-informed" about selected issue areas. Although those individuals who are objectively more knowledgeable are significantly more likely to describe themselves as being very well-informed, there are some individuals who have a relatively high level of understanding as measured by objective indicators, who aware of the depth of understanding held by professionals in the field, describe themselves as moderately well-informed. Conversely, some individuals who feel well-informed may not display a high objective level of understanding. The point of this concept is that individuals who think they are very well-informed are significantly more likely to participate in public policy disputes than are citizens who have some doubts about their level of understanding (Rosenau 1974 and Miller 1983a).

education; however, the proportion of adults reporting a high level of interest in issues about the use of nuclear power and about environmental pollution was not related to either the level of formal schooling or the level of science and mathematics coursework.

This pattern of differences by level of education appears in analyses throughout this chapter. Science and scientific issues are seen as more difficult subjects that require more study or knowledge than other kinds of issues. Technologies—or technology-related issues such as nuclear power and environmental issues—appeared to be more familiar to more respondents, and might be seen as more directly affecting their lives. Therefore, interest in these technological areas appears to be less

Primary Data Sources

The analysis reported in this chapter rests primarily on four major data sources, as described below.

- **NSF Survey of Public Understanding of Science and Technology, 1979-92:** Most of the U.S. data in this chapter come from a series of national surveys funded by the National Science Foundation (NSF). The most recent survey, conducted in 1992, consisted of telephone interviews with 2,001 adults aged 18 and over in a national probability sample. It contained a core of questions that have been asked in these studies since 1979.
- **NIH Survey of Public Understanding of Biomedical Concepts, 1993:** In a joint program with NSF, the National Institutes of Health (NIH) sponsored a national study of public understanding of biomedical concepts. A total of 3,111 telephone interviews were conducted, using a national sample stratified by race/ethnicity. Within each stratum, a national probability sample was selected, but oversamples of college graduates were collected in the black and Hispanic strata to compensate for the distribution of educational attainment. The final analytic file was weighted to reflect the U.S. population.
- **Eurobarometer 38-1:** Continuing its 20-year series of biennial surveys, the Commission of the European Communities conducted a survey of 13,024 adults in its 12 member nations in fall 1992. The interviews were conducted in person in the native language of the respondent.
- **Japan National Study, 1991.** Sponsored by the National Institute of Science and Technology Policy (NISTEP), the 1991 study was based on in-person interviews with 1,457 adults aged 18 and over. A core set of questions were designed to allow comparisons with the *Eurobarometer* studies and the U.S. Science Indicators studies.
- **Data Availability.** The *Eurobarometer* data can be obtained from Zentralarchiv fur Europaische Socialforschung, Köln Universitat, Germany (Fax: 49-221-476-9444) and Institute of Social Research, University of Michigan, USA (Fax: (1)-313-747-45-75). Data for all four sources are available from the International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences. (Internet: icasl@mcs.com) Fax: (312) 549-5199 Phone: (312) 549-0606

related to formal schooling. Space exploration, while depending on a wide range of technologies, tended to be less salient to most respondents.

International Comparisons. Looking at the patterns of interest in these same four issue areas in Japan and the 12 nations of the European Community, the United States ranks ninth with regard to the level of interest in issues about new scientific discoveries, sixth regarding the use of new inventions and technologies, and sixth regarding environmental issues. (See figure 7-3.) It ranks first in the proportion of citizens expressing a high level of interest in new medical discoveries. Very high levels of citizen interest in all four issues were found in France, the Netherlands, Italy and Greece. Japan ranked last, or next to last, in level of citizen interest in all four S&T-related issue areas.

Informedness on S&T Issues

U.S. Public. Despite their high level of interest in science and technology, only about 1 in 10 American adults thinks of him or herself as very well-informed about either *new scientific discoveries* or the use of *new inventions and technologies*. Since the initiation of this question series in 1979, not more than 14 percent of American adults have been willing to classify themselves as very well-informed on these issues. (See figure 7-1.) In 1992, only 12 percent of American adults claimed to be very well-informed about new scientific discoveries, and only 10 percent made this claim regarding issues on the use of new inventions and technologies. A similar proportion indicated that they were very well-informed on issues about the use of nuclear power. Nearly twice as many Americans thought of themselves as very well-informed about *new medical discoveries* (slightly over 20 percent). This level of self-reported knowledgeability has been stable since it was first measured in 1985.

The proportion of Americans who feel well-informed about *economic and business condition* issues has remained in the mid- to upper 20-percent range throughout the 1980s. (See figure 7-1.) In 1992, nearly 30 percent of Americans thought they were very well-informed in this area—the same proportion as in 1981, a period of intense public discussion of economic issues.

For virtually every issue area, the proportion of Americans reporting a high level of *informedness* is significantly lower than the proportion reporting a high level of *interest*. Although the level of interest in scientific and technical issues has remained high, fewer than one in three respondents think of themselves as well-informed about these same issues.

Significant differences in level of informedness exist among various segments of the public. Higher proportions of adults with more formal education reported that they were very well-informed about new scientific discoveries and space exploration. This pattern was not as clear with regard to issues on the use of new inventions and technologies, new medical discoveries, and environmental pollution. (See figure 7-2.) In all of the areas included in the study, there was a tendency for a relatively high proportion of respondents with 9 years or less of formal schooling to claim to be very well-informed. (See appendix table 7-5.) Given the results on actual knowledge tests, this high response rate may be a reflection of not knowing enough about these complex fields to be able to assess their own level of knowledgeability accurately.

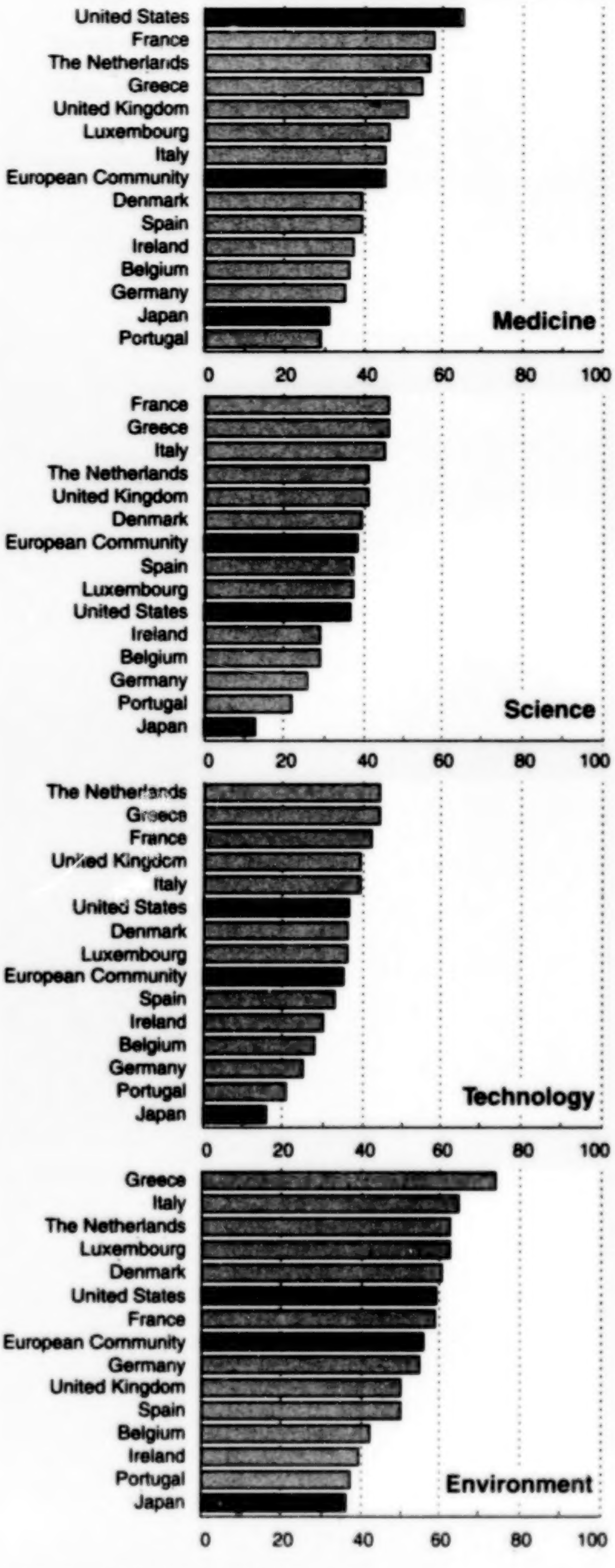
International Comparisons. When adults from 14 nations were asked to assess their level of informedness in these same four areas (new medical discoveries, new scientific discoveries, new inventions and technologies, and environmental pollution), fewer than half of those who claimed to be very interested in each area were willing to classify themselves as very well-informed in that area. The relative ranking among the nations changed only moderately. (Compare figures 7-3 and 7-4.)

A higher proportion of Americans thought of themselves as very well-informed about new medical discoveries than did citizens in any other nation. The proportion of Americans claiming to be very well-informed about new scientific discoveries, the use of new inventions and technologies, and environmental pollution was higher than the European average. (See figure 7-4.) About 1 in 10 Americans and Europeans thought they were very well-informed about new scientific discoveries and new technologies. Generally, within the European Community, higher proportions of French, Dutch, Luxembourg and Danish citizens thought of themselves as well-informed across these four areas than did other national groups. Among all countries studied and for all topic areas, Japan had the lowest proportion of citizens claiming to be very well-informed.

Attentiveness to S&T Issues

The United States is a pluralistic society. Some individuals may have a strong interest in economic, agricultural, or foreign policy issues, and less interest in issues involving science or technology. Conversely, other individuals may follow S&T policy issues closely, but have little interest in agricultural, housing, transportation, foreign policy, or other issues. It is impossible for all citizens to pay attention to every issue area. Thus, in this competition for attention and involvement, it is useful to examine the levels of interest the public devotes to science and technology and to seek to identify those segments of the public that report the highest levels of interest in, informedness on, and attention paid to scientific and technical issues.

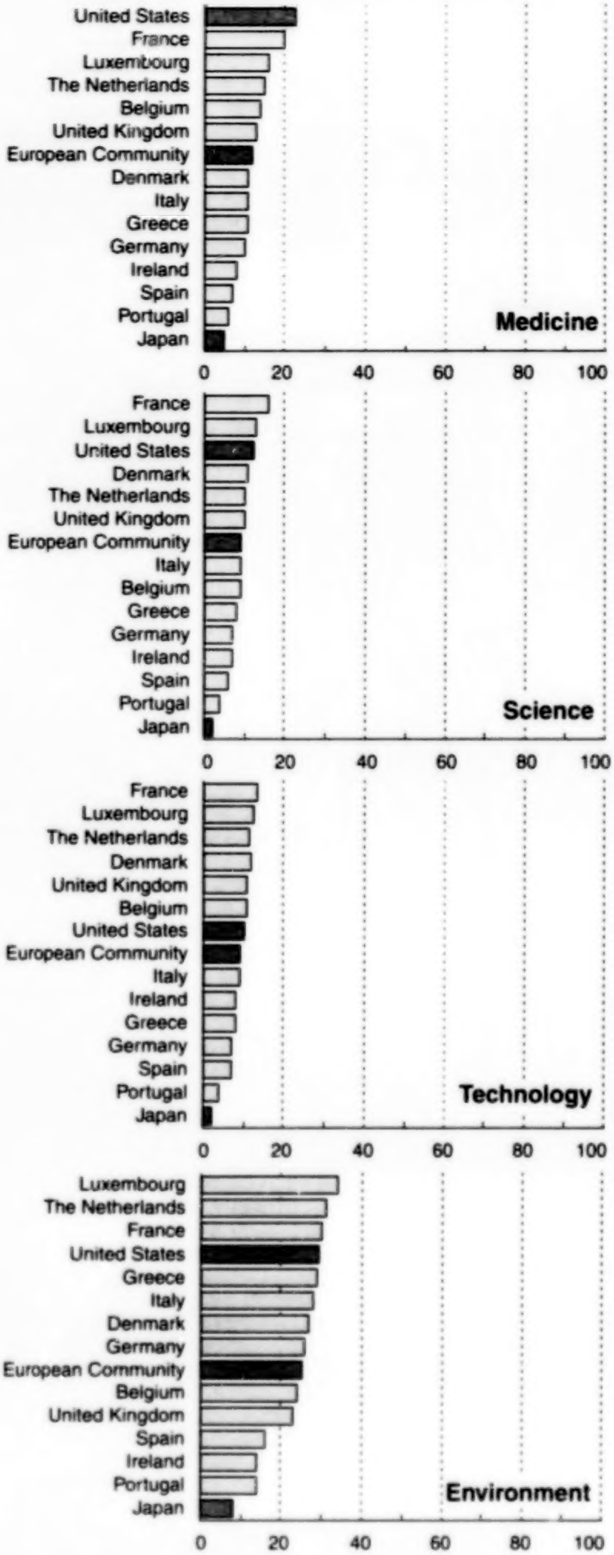
Figure 7-3.
Interest in scientific issues, by country: 1992



NOTE: Japanese data are for 1991.

See appendix table 7-3. *Science & Engineering Indicators – 1993*

Figure 7-4.
Informedness on scientific issues, by country: 1992



NOTE: Japanese data are for 1991.

See appendix table 7-6. *Science & Engineering Indicators – 1993*

Citizens who display a high level of interest in an issue area, who believe that they are well-informed about it, and who display a pattern of current information consumption are classified as ***attentive*** to that issue.[2] Individuals with a high level of interest in an area, but who think of themselves as not being well-informed about that area, are classified as members of the ***interested*** public. Those without a high level of interest in an issue area are referred to as the ***residual*** public in that issue area.

Approximately 10 percent of American adults (or about 18 million individuals) were included in the attentive public for science and technology policy. (See figure 7-1.) This proportion is slightly down from 1979. Comparatively, the proportion of adults attentive to economic issues and to new medical discoveries increased in the early 1980s to slightly less than 20 percent of the adult population and remained at that level for the last decade. About one in five Americans was attentive to issues about environmental pollution in both 1990 and 1992. (See appendix table 7-7.)

A higher proportion of males was attentive to S&T policy than females, but the difference was not substantial. (See figure 7-5.) Interestingly, attentiveness to S&T policy was not significantly associated with the level of formal education completed.

These results indicate that the pool of likely citizen participants in a policy dispute involving S&T would be

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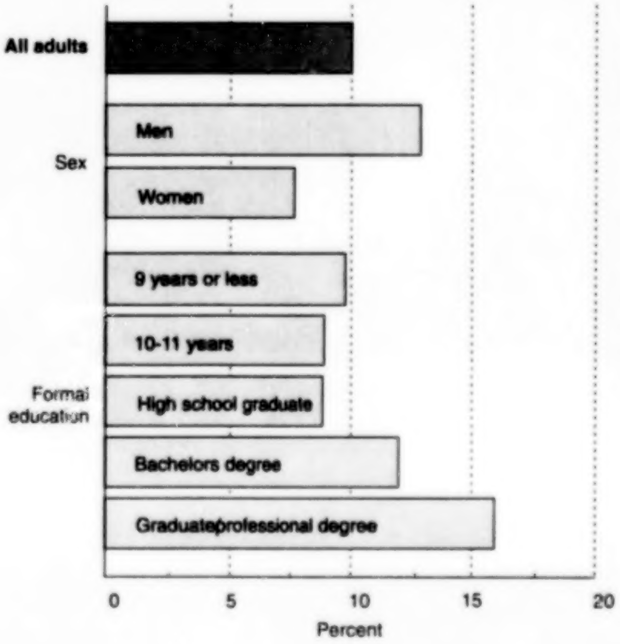
[2] For a general discussion of the concept of issue attentiveness, see Almond (1950), Rosenau (1974), and Miller (1983a).

Figure 7-5.
Attentiveness to science and technology policy: 1992



See appendix table 7-8. *Science & Engineering Indicators – 1993*

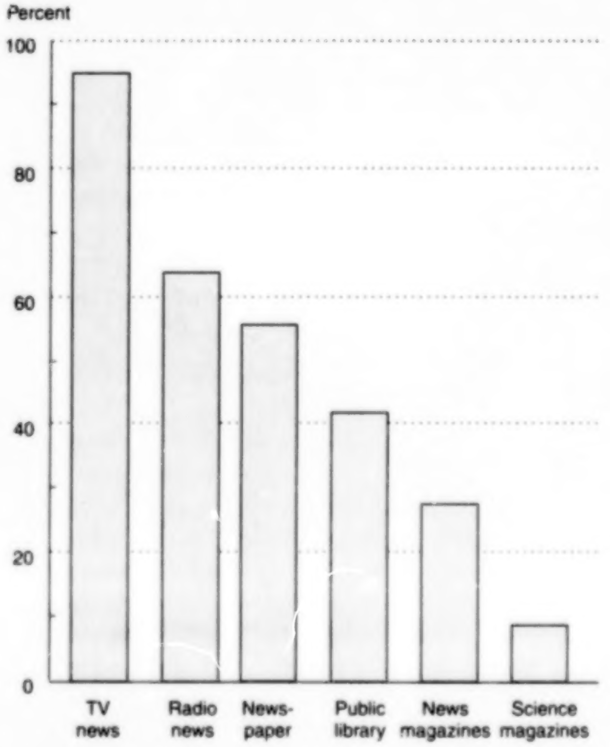
limited to about 10 percent of the total adult population. Previous research suggests that only a small proportion of this group would likely be mobilized to participate actively in the debate by writing letters or calling legislators (Rosenau 1974 and Miller 1983a).

Sources of Information

Information Sources for S&T. Given the pace of change in science and technology, most individuals cannot—in their adult roles as worker, consumer, parent, and citizen—rely solely on the science and mathematics they may have learned in school. This section explores the alternative sources of information the public uses most frequently to learn about new developments in S&T and the trust citizens have in these sources.

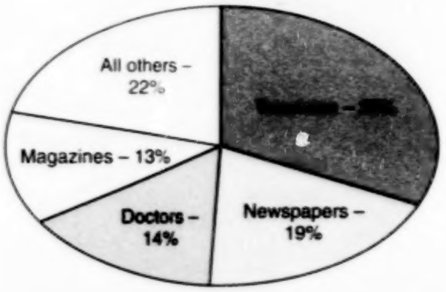
Television continues to be the most frequently used information source. Ninety-five percent of American respondents indicated that they watched at least an hour of television news almost every day. Nearly two-thirds reported listening to an hour or more of news on the radio almost every day. On the print side, 56 percent of adults reported that they read a newspaper almost everyday, while 28 percent read a news magazine regularly. Conversely, only 9 percent of adults reported that they read a science magazine regularly. This array of results points to a high level of information consumption in both the broadcast and print media among American adults. (See figure 7-6.)

Figure 7-6.
Public use of selected information sources: 1992



See appendix table 7-9. *Science & Engineering Indicators – 1993*

Figure 7-7.
Primary source of health information: 1993



See appendix table 7-10. *Science & Engineering Indicators – 1993*

Seventy percent of the respondents reported that they used a public library at least once during the previous year; 42 percent indicated that they visited five or more times. Note, however, that although public libraries provide access to a wide array of books, magazines, and reference materials, many also lend out videotapes and other kinds of entertainment media.

Primary Information Sources for Health and Medical Topics. Additional insight can be gained on how individuals obtain information—and how much they trust those sources—by looking at data on how the public obtains information on health and medical topics. A 1993 study of the public understanding of biomedical science asked respondents to report their primary source of information on health and medical issues.[3] Respondents were also asked how much they would trust selected sources for information about heart disease and for information concerning how to lose weight.

Approximately one-third of American adults reported that they get most of their health information from television; another third reported that they relied on either newspapers or magazines; and a little under a sixth said they got most of their health information from a physician. (See figure 7-7.) In broad terms, better educated respondents reported greater reliance on print materials, while less well-educated individuals relied more often on television. There were few differences between men and women, with men relying slightly more on newspapers and women relying slightly more on magazines.

When asked how much they would trust information from each of these sources on two different health topics (heart disease and weight loss), major differences emerged. Individuals reported that they had more confidence in information on heart disease from each source

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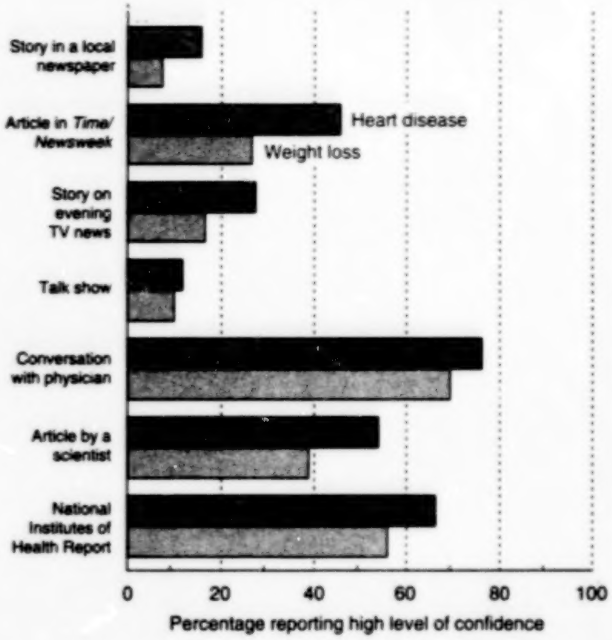
[3] The 1993 study of the public understanding of biomedical concepts was supported by the National Institutes of Health in cooperation with the National Science Foundation. A more complete description of the study is included in "Primary Data Sources."

Figure 7-8.
Public trust in various health information sources: 1992



See appendix table 7-11. *Science & Engineering – 1993*

than they would have in information from that same source concerning losing weight. (See figure 7-8.) A large segment of the public apparently has little confidence in weight loss information, possibly reflecting the commercialization of this topic and the frequent media promotion of special diets.

Within each subject area, Americans reported major differences in the level of confidence in information by source. (See figure 7-8.) About three-quarters of the respondents reported a high level of confidence in information from a physician concerning heart disease; such confidence was expressed by only 12 percent for information on this topic provided on a television talk show. A similar pattern of trust was reported for information about weight control or loss, except—as noted above—the overall level of confidence was lower. Thus, nearly 70 percent of respondents reported that they would have a high level of confidence in weight loss information from a physician, and fewer than 10 percent would trust information from a television talk show. A very small proportion of respondents reported a high level of confidence for information from a local newspaper.

In general, better educated respondents were more likely to trust information from the National Institutes of Health (NIH) or a scientist than were less well-educated individuals. Respondents with less formal education were more likely to trust information from a television news or talk show than were better educated individuals. There were no substantively important differences in information trust between men and women.

Looking at the data in terms of ***primary*** health information source reveals some interesting insights. (See text table 7-1.) For the topic of heart disease, only those adults who cited their physician as their primary source reported a high level of confidence in their primary health information source. Among those citing ***television*** as their primary health information source, only a third had a high level of confidence in information from a television news show, and only about a sixth (15 percent) had a high level of confidence in information from a television talk show.

About half of the respondents who cited ***magazines*** as their primary health information source indicated that they would have a high level of confidence in heart disease information obtained from a magazine like *Time or Newsweek*. In contrast, among those adults who reported that they relied on ***newspapers*** as their primary health information source, only 16 percent indicated a high level of confidence in heart disease information published in their local newspaper.

The level of confidence in information about weight loss was significantly lower than the level of confidence in information about heart disease, regardless of the information source or the specific medium. As suggested above, it is likely that this result reflects the more scientific and "credible" character of heart disease information and the more commercialized approach to weight loss in most media. Moreover, it demonstrates that most segments of the public make some distinctions about the credibility of health-related information sources.

Attitudes Toward S&T

Within these patterns of issue interest, informedness, and information acquisition, it is important to understand the attitudes of Americans toward science and technology in general and toward some current policy issues. The preceding indicators of interest, informedness, and information acquisition have been content neutral. For example, some respondents who reported a high level of interest in new scientific technologies or the use of new inventions and technologies may hold very positive attitudes toward organized science or toward specific science

Text table 7–1.
Trust in health information, by primary source of information: 1992

Primary source	Heart disease			Weight loss		
	High	Low	N	High	Low	N
	Percent			Percent		
TV evening news	33	9	494	17	28	498
TV talk shows	15	42	494	12	51	498
Local newspaper	18	14	278	12	32	300
Time or *Newsweek*	52	7	175	24	19	217
Physician	86	3	212	76	3	240

SOURCE: Miller and Pifer, 1994a.
Science & Engineering Indicators – 1993

policy issues, while other individuals reporting the same level of interest may hold negative or opposing attitudes. Analysis of these differences can help in understanding the landscape of public interest and informedness, as well as in grasping the substance of the public's thinking about science and technology.

This section focuses on the pattern of general attitudes toward science over recent decades and examines the distribution of attitudes among selected segments of the public. Beyond broad general attitudes, this section examines public expectations about future outcomes of S&T, current assessment of the benefits and risks of scientific research, and preferences regarding government spending for S&T.

General Attitudes Toward S&T

U.S. Public. Periodic surveys of public attitudes toward organized science[4] over the last decade indicate that most Americans continue to hold a positive view of science and technology. A four-item scale reflecting general attitudes toward S&T, referred to as the Attitude Toward Organized Science Scale (ATOSS), shows a positive stable attitude toward organized science over the last decade.[5] (See text table 7-2.) Individuals with higher levels of formal education tended to hold more positive views of organized science than did less well-educated respondents. Similarly, a higher proportion of citizens who were attentive to S&T policy held more positive attitudes. By 1993, there were no differences in the attitudes of men and women toward organized science.

International Comparisons. A higher proportion of Americans hold positive attitudes toward science and technology than do the citizens of Japan and the European Community. While over 80 percent of both Americans and Europeans agreed that S&T are making "our lives healthier, easier, and more comfortable," fewer Americans (38 percent) thought it made "our way of life change too fast," compared to the majority of European Community (55 percent) and Japanese (57 percent) respondents. (See appendix table 7-14.)

When asked to assess the impact of computers and factory automation on the creation of new jobs, Japanese residents were the most optimistic, with 43 percent agreeing that computers and automation would create more jobs than they would eliminate. In contrast, only 19 percent of European adults shared that view. Among Americans, 39 percent agreed that more jobs would be created than eliminated.

Text table 7–2.
Mean scores on the Attitude Toward Organized Science Scale

	1983	1985	1988	1990	1992
All adults	2.3	2.5	2.7	2.6	2.7
Males	2.2	2.4	2.6	2.5	2.7
Females	2.5	2.6	2.8	2.8	2.6
Less than high school degree	1.8	1.8	2.2	1.8	2.0
High school degree	2.4	2.6	2.8	2.7	2.7
College degree	2.8	3.1	3.2	3.2	3.2
Graduate/professional degree	2.9	3.1	3.1	3.2	3.3
Attentive public	2.6	2.8	3.0	2.8	2.9
Interested public	2.4	2.6	2.8	2.7	2.8
Residual public	2.1	2.3	2.5	2.5	2.5

NOTE: Data represent mean scores on a scale of four items.

See appendix table 7-13. *Science & Engineering Indicators – 1993*

Confidence in Institutional Leadership

Over the last 20 years, the General Social Survey (GSS) has asked national samples of American adults to rate their confidence in the leadership of major national institutions.[6] Consistently over this period, the leadership of medical and scientific communities has been among the most trusted in the nation—more so, for example, than the leadership of the Supreme Court. (See figure 7-9.) In 1993, approximately 40 percent of American adults expressed a high level of confidence in the leadership of these communities, a slight increase over the 37-percent level in 1990.

The public tends to regard the leadership of the press and of television with a relatively low level of confidence. In the context of the above analysis of information sources and public confidence in them, these results suggest that there is a broad and continuing low level of trust of television and of newspapers and other print media. The relative levels of confidence reported regarding heart disease and weight loss may reflect a more generic distrust of media.

Attitudes Toward the Work of Scientists

While the public generally holds positive attitudes toward the leadership of organized science and toward organized science as an institution, they hold mixed views of the work of scientists. (See figure 7-10.) In 1992, nearly 80 percent of Americans thought that scientists "want to work on things that will make life better for the average person." However, over 50 percent agreed with the statement that "many scientists make up or falsify research results to advance their careers or make money." The tendency to believe that many scientists falsify results was only partially offset by a recognition that the scientific tradition of repeating other scientists' work provides a check on fraud or cheating.

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[4] "Organized science" refers to the total scientific and engineering community. It is a shorthand reference that should be interpreted to include scientists, engineers, and related support personnel and the institutions in which they work.

[5] Substantively, the four items in the ATOSS Scale cover some important aspects of general attitudes toward organized science. Specifically, respondents are asked to react to the statements "science and technology are making our lives healthier, easier, and more comfortable"; "science makes our way of life change too fast"; and "we depend too much on science and not enough on faith." The fourth component on the scale asks respondents to make a relative judgment about the benefits and potential harms of scientific research. The scale score is calculated by counting the number of responses that represent a positive assessment of organized science. The scale ranges from 0 to 4. The value of using a scale is that it reduces response error and provides a more accurate estimate than would use of any one item alone.

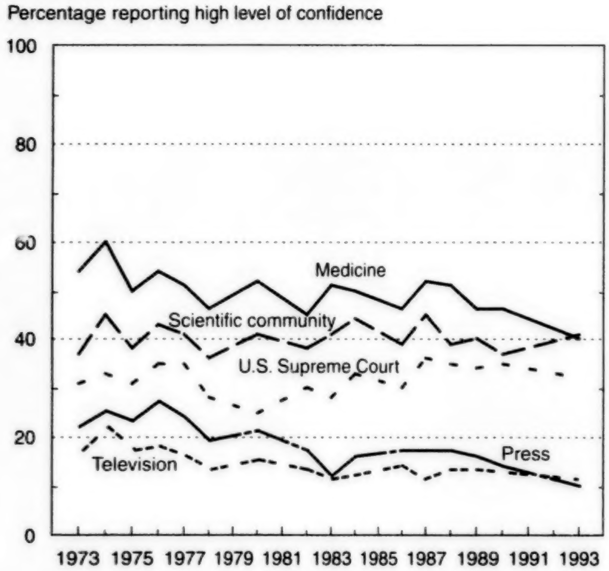
[6] Since 1972, the National Opinion Research Center at the University of Chicago has conducted a national survey of social attitudes, referred to as the General Social Survey. Using personal interviews, the GSS has collected data from a national probability sample of approximately 1,500 individuals annually or biennially. See Davis and Smith (1993).

Overall, better educated respondents were more likely to concur that traditional repetition and checking will detect and prevent fraud and less likely to agree that many scientists falsify research results. And approximately 80 percent of all adults—regardless of sex or education level—agreed that most scientists want to work on things that will benefit the average person.

Expectations for S&T

When asked to think about the likelihood of future scientific achievements, Americans display both optimism and pessimism. (See figure 7-11.) For example,

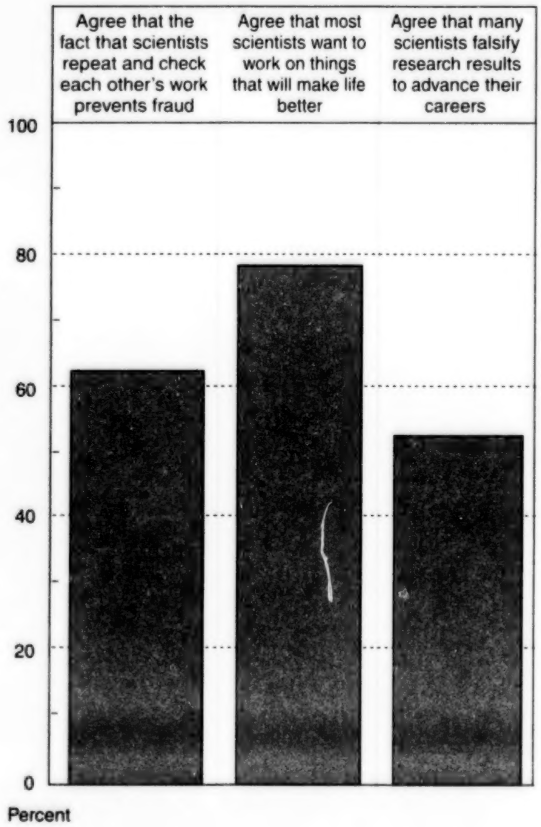
Figure 7-9.
Public confidence in leadership of selected institutions



NOTE: The survey was not conducted in 1979 and 1981, and the question was not asked in 1985.

See appendix table 7-12. *Science & Engineering Indicators – 1993*

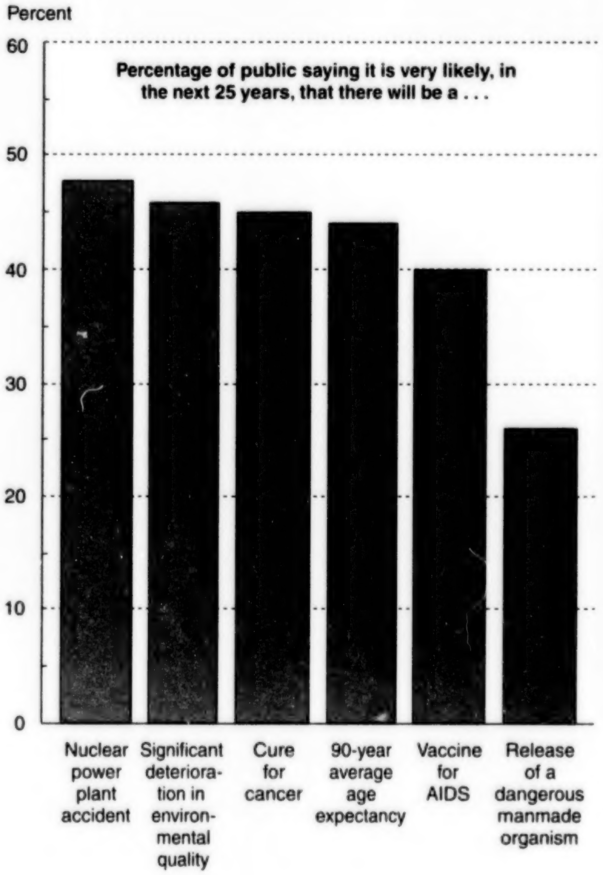
Figure 7-10.
Public attitudes toward scientists: 1992



NOTE: See appendix table for exact wording of statements.

See appendix table 7-15. *Science & Engineering Indicators – 1993*

Figure 7-11.
Expected results from science and technology: 1992



NOTE: See appendix table for exact wordings of statements.

See appendix table 7-16. *Science & Engineering Indicators – 1993*

- 45 percent of Americans think that medical scientists will find a cure for the common forms of cancer within the next 25 years, 40 percent anticipate the development of a vaccine for AIDS, and 44 percent expect that new medical technologies will be developed to extend the average lifespan to 90 or more years in the United States; but
- nearly half expect a major nuclear power plant accident within the next 25 years, half think that there will be "a significant deterioration in the quality of our environment" over the next quarter century, and a quarter think it is very likely that a "dangerous manmade organism" will be released into the environment accidentally in the next 25 years.

Clearly, most Americans expect a mixture of beneficial and harmful results from science and technology.

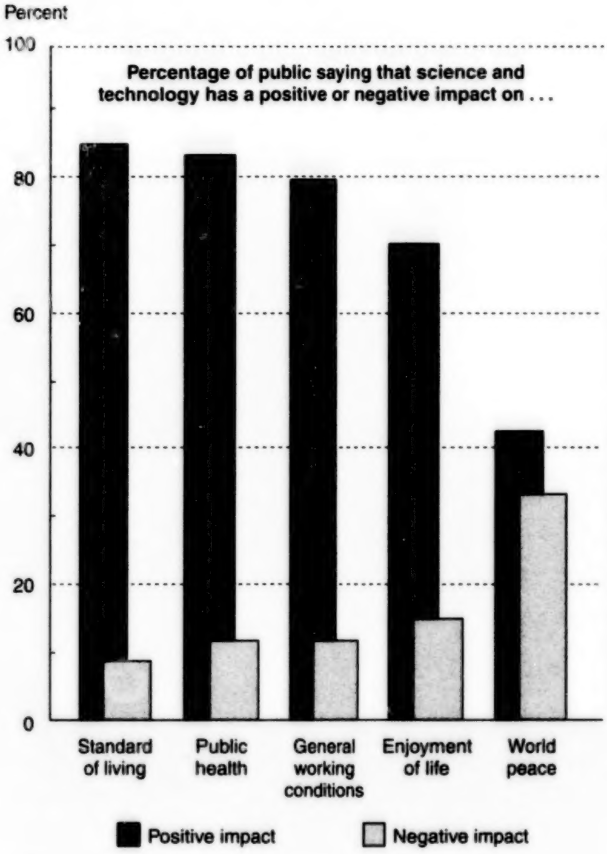
Consistent with the previous results, individuals with higher levels of formal education were more likely to anticipate positive results from science. But there was no significant difference by level of education in the expectation of a nuclear power plant accident or the deterioration of the environment. There was a weak relationship between the level of education and the expectation of the release of a dangerous manmade organism, but this may be a reflection, in part, of a differential level of understanding of the concept of a "manmade organism."[7]

Impact of S&T

In 1985 and 1992, national samples of individuals were asked to assess whether S&T had a positive, negative, or no impact on several aspects of the quality of life. Comparing the results from these two surveys reveals a very positive attribution to science and technology of a high standard of living, improved working conditions, improved public health, and an increased enjoyment of life by individuals. (See figure 7-12.) Even in the case of world peace, a plurality of respondents in both years thought that the contribution of S&T had been more positive than negative; this margin of difference increased between 1985 and 1992.

Individuals with higher levels of formal education tended to hold more positive views of the contribution of science and technology to the quality of life, possibly reflecting qualitative differences in quality of life experiences by the different education strata in American society. There were no significant differences between the assessments of men and women on S&T's impact on the quality of life, and there were no differential changes between 1985 and 1992.

Figure 7-12.
Impact of science and technology on quality of life issues: 1992



See appendix table 7-17. *Science & Engineering Indicators – 1993*

Assessment of Benefits and Costs

U.S. Public. Most Americans believe that science and technology have produced both desirable and undesirable results, and expect these mixed results to continue. The public attitude studies conducted for *Science & Engineering Indicators* since 1979 have asked national samples of Americans to determine whether, on balance, the results have been more beneficial or harmful. Their responses indicate that at least 7 of 10 Americans have concluded that the balance has favored beneficial results throughout this period. (See figure 7-13.) Fewer than one in five Americans reached the opposite conclusion during this 14-year period.

Seventy-three percent of all adults in 1992 concluded that the benefits of scientific research outweighed its harmful consequences; better educated respondents were more likely to assess the balance as strongly favoring beneficial over harmful results. This finding may indicate that more exposure to education or to science and mathematics results in a more positive assessment of the net benefit of S&T to society.

International Comparisons. In comparisons with other industrial nations, residents of the United States are the most likely to conclude that the benefits of scientific research have outweighed any actual or possible harm, followed by those of Denmark, Spain, and France. (See figure 7-14.) Japanese citizens were the least likely to believe that the benefits outweighed the possible harms, with only 40 percent of Japanese respondents holding that view.

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[7] Note too that these data were collected before the movie "Jurassic Park" was released, and so are unlikely to reflect the genetic engineering concerns popularized by the book and movie.

Attitudes Toward Government Spending for S&T

Another estimate of public attitudes toward science and technology can be obtained by asking respondents to assess government spending for various kinds of programs. Since few citizens have a clear understanding of what the actual government expenditures are for specific programs, the results of inquiries about government spending should be taken as a general indicator of the importance that a respondent attaches to various programs.[8]

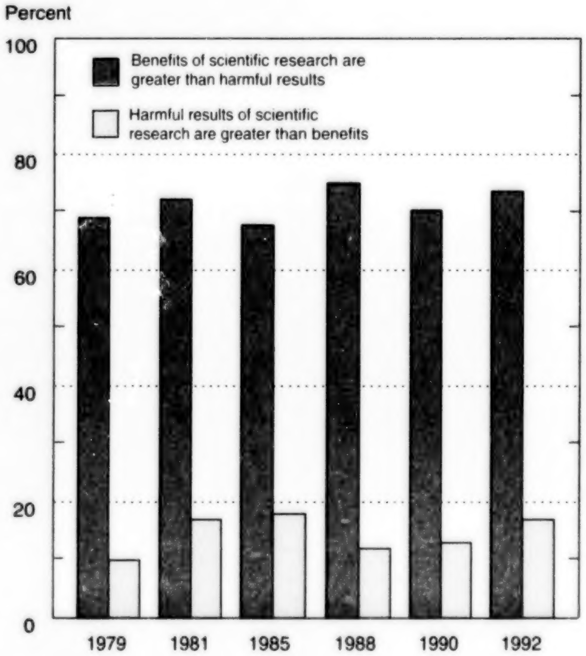
Over the last decade, 34 percent of those surveyed reported that they think the government is spending too little on scientific research, while fewer than 20 percent indicated that the government is spending too much. (See figure 7-15.) A near majority of Americans think that the level of government support for scientific research is "about right." Individuals with high levels of formal education and those who are attentive to S&T policy were more likely to think that the government is spending too little for scientific research. (See appendix table 7-20.)

In comparison, a substantial majority of Americans reported in 1992 that they thought the government was spending too little on improving education (81 percent), improving health care (79 percent), helping older persons (73 percent), reducing pollution (72 percent), and helping low-income people (56 percent). Forty percent of Americans thought that the government is spending too much on defense; about 50 percent thought the government was spending too much on space exploration. Taken as indicators of support rather than as funding judgments per se (see above), these results suggest that most Americans favor continuing the present levels of support for scientific research and an increased emphasis on education, health, and related social programming.

Public Understanding of Science

In many nations throughout the world, there is broad agreement that economic, social, and political advantages exist in increasing the proportion of the population that is scientifically literate (Miller 1983b). Setting aside the construction of a single definition of scientific literacy, it is useful to look at the level of public understanding of major terms and concepts in basic science, in biomedicine, and in ecology.

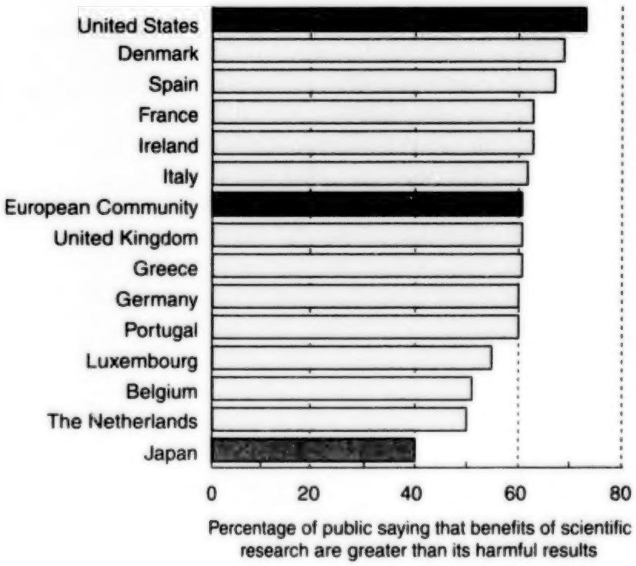
Figure 7-13
Assessments of scientific research over time



NOTES: Survey was only conducted in years shown. Data reflect responses of people saying that benefits (harms) exceed or strongly exceed harms (benefits).

See appendix table 7-18. *Science & Engineering Indicators – 1993*

Figure 7-14.
Assessments of scientific research, by country: 1992



NOTE: Japanese data are for 1991.

See appendix table 7-14. *Science & Engineering Indicators – 1993*

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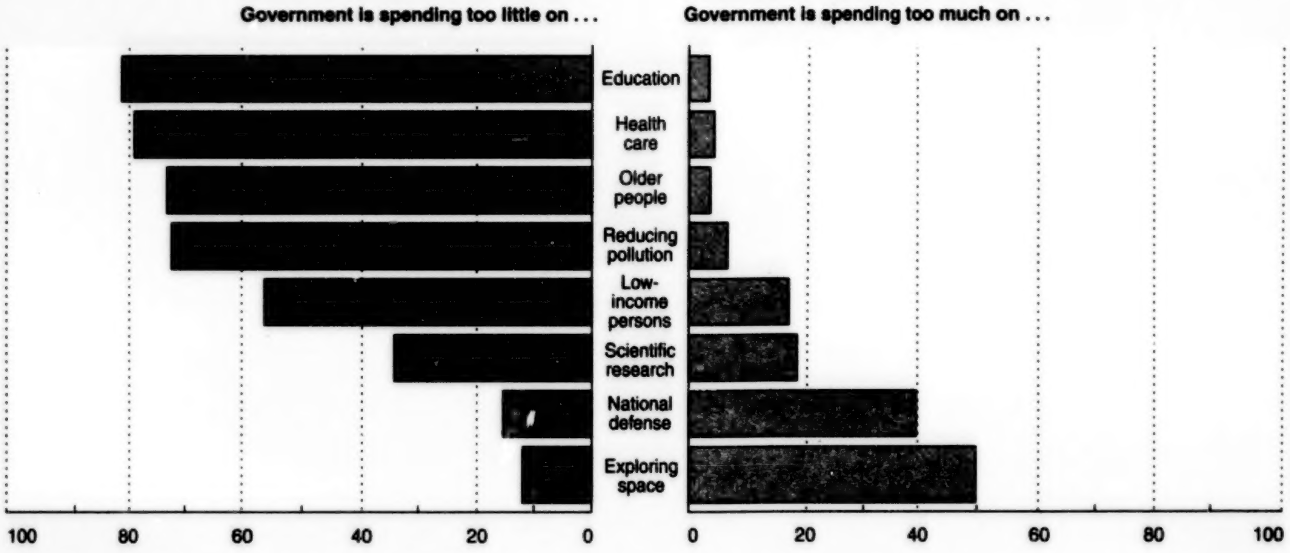
[8] For a variety of reasons—including the intangible, abstract nature of the large sums involved in federal budgets—only in the rarest of cases does a survey response represent a real, informed budgetary judgment.

Figure 7-15.
Preferences for government spending: 1992



NOTE: See appendix table for exact wordings of statements.
See appendix table 7-19 and 7-20.

Science & Engineering Indicators – 1993

Understanding of Scientific Terms and Concepts

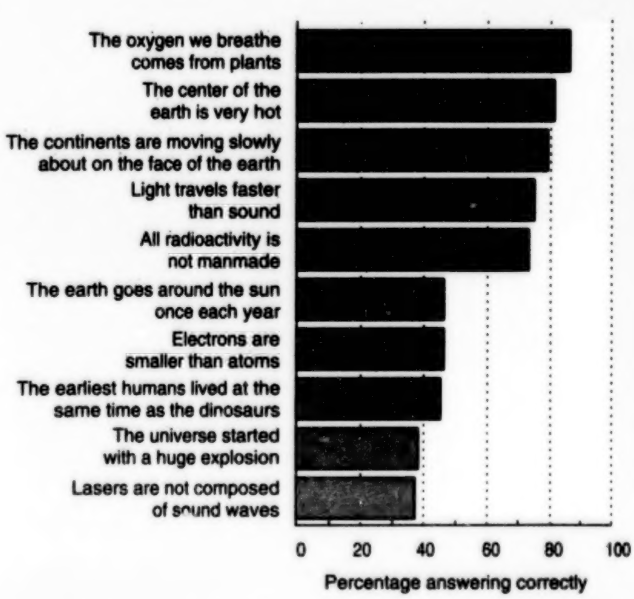
The process of information acquisition in today's world requires citizens to be able to read about current developments in science and technology. One prerequisite for effective information acquisition about S&T is the possession of a basic vocabulary of scientific terms and concepts. The 1992 *Science & Engineering Indicators* study included a set of questions on basic scientific terms and concepts to use in understanding key aspects of the our world. (See figure 7-16.)

U.S. Public. A substantial majority of Americans understood that oxygen comes from plants, that the center of the earth is very hot, that continents move on the surface of the Earth (i.e., plate tectonics), that light travels faster than sound, and that all radioactivity is not manmade. However, fewer than half of the respondents knew that the earth travels around the sun once a year or that electrons are smaller than atoms; about the same proportion did not accept the idea of evolution. While the responses indicate some understanding of the planet, a majority of adults apparently do not understand the nature of the solar system or the origins of stars or galaxies. The American understanding of science is, indeed, rather earthbound.

International Comparisons. The United States ranked in the top third of the countries from which data are available on public understanding of scientific terms and concepts. Using a set of 12 items to gauge public understanding, the United States ranked fourth, trailing Denmark, the United Kingdom, and France. (See figure 7-17.) Across the 12 items, U.S. respondents had a mean percentage correct of 58 percent, compared to 55.5 percent for the European Community.

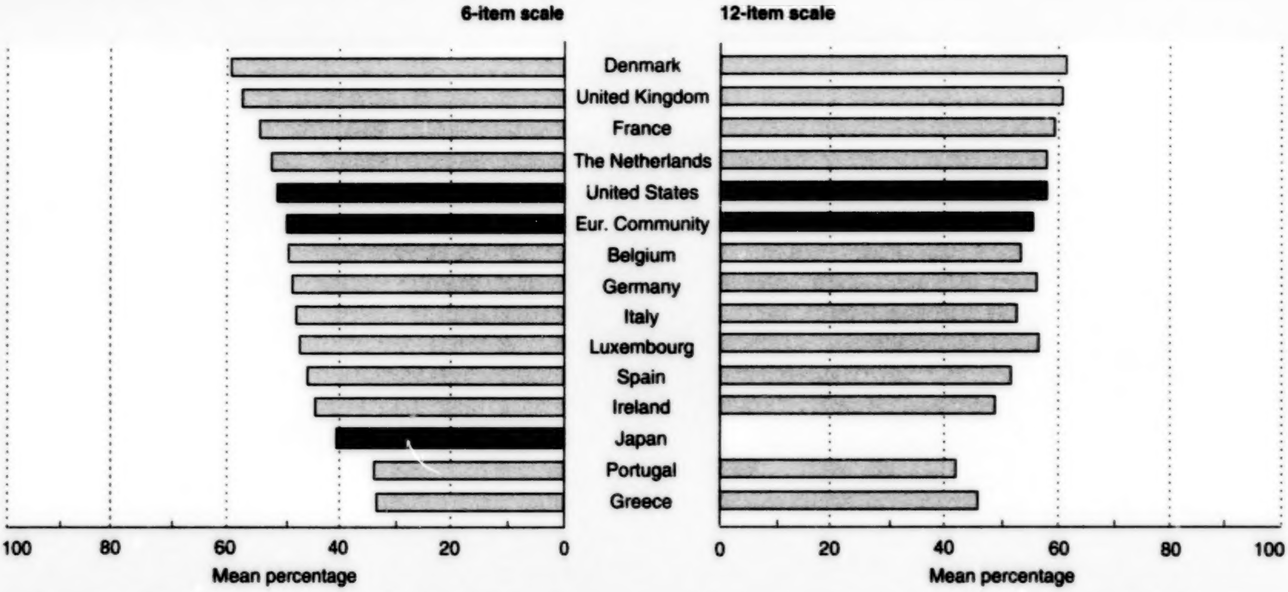
In the 1991 Japanese study, only 6 of these 12 items were asked. (See appendix table 7-22 for the exact components of the 6- and 12-item scales.) A similar mean

Figure 7-16.
Knowledge of basic scientific terms and concepts: 1992



See appendix table 7-21. *Science and Engineering Indicators – 1993*

Figure 7-17.
Knowledge of basic scientific terms and concepts, by country: 1992



NOTES: Respondents demonstrated their understanding of 6 or 12 basic scientific and technical terms and concepts (see appendix table for exact question wording); data reflect mean percentage correct for respondents within each country. Japanese data are for 1991; no data are available for Japan on the 12-item scale.

See appendix table 7-22.

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percentage correct score was calculated for all 14 countries on these six items. On this shorter index, the United States ranked fifth, following Denmark, the United Kingdom, France, and the Netherlands. Japan ranked 12th on this scale, with a mean percentage correct of 41 percent.

Understanding of Biomedical Terms and Concepts

To understand public policy discussions and to make decisions concerning personal health, it is increasingly useful for an individual to understand basic genetic and biological concepts. A 1993 national study cosponsored by NIH and NSF asked respondents about a set of basic biomedical terms and concepts. The results indicate a generally higher level of comprehension than the preceding set of scientific terms and concepts, but there are still important areas of misunderstanding.

Over 80 percent of adults understood that not all bacteria are harmful to human beings, and 77 percent recognized that the human immune system can protect individuals from both viruses and bacteria. (See figure 7-18.) Previous *Science & Engineering Indicators* studies found that only 35 percent of American adults knew that antibiotics do not kill viruses.

About 75 percent of Americans knew that human intelligence is not related to the size of the brain, and 63 percent thought that the process of evolution is continuing presently. This latter response is confusing, since only 41 percent of respondents in the same 1993 study indicated that they thought human beings had developed from earlier species of animals. In any case, these results suggest that there exists a substantial level of confusion in the public about the scope and nature of evolution.

Six of ten Americans thought that DNA regulates inherited characteristics in both plants and animals, but in a separate open-ended question about the meaning of DNA, only 20 percent of respondents could provide a response that included the regulation of heredity. In the open-ended format, an additional 20 percent could link DNA to the words "gene" or "chromosome," but it was unclear from the total response whether they understood the linkage to inheritance. From these results, it appears that an increasing proportion of Americans are becoming familiar with the term DNA and the concept of genetic control of inherited characteristics, but that many adults are still confused about these concepts.

Understanding of Environmental Terms and Concepts

As governments struggle to understand and cope with environmental issues—from the thinning of the ozone layer to the pollution of the oceans—it will be important for a significantly large segment of the public to understand both the nature of environmental problems and the available public policy alternatives. In this context, the 1992 *Science & Engineering Indicators* study included a set of questions to measure the understanding of selected environmental terms and concepts. (See "Environmental Interest and Knowledge in the European

Community and the United States" for international comparisons in this area.)

The results of the 1992 study point to substantial gaps in the public understanding of environmental science concepts. When asked in an open-ended format to explain the causes of acid rain, only 8 percent of American adults could provide a minimally correct response and an additional 5 percent could provide some general description of its effects. (See figure 7-19.) Nearly 40 percent referred to acid rain as a form of pollution, but could provide no additional details about its origins and consequences.

A larger proportion of the public was able to demonstrate a minimal understanding of the thinning of the ozone layer. When asked a series of open-ended questions about the thinning of the ozone layer, 25 percent of American adults could provide a minimally acceptable explanation for the thinning of the layer,[9] and 42 percent were able to describe correctly some of its harmful consequences. (See figure 7-19.) However, only 7 percent of respondents could correctly identify the location of the major thinning—or hole—in the ozone layer.

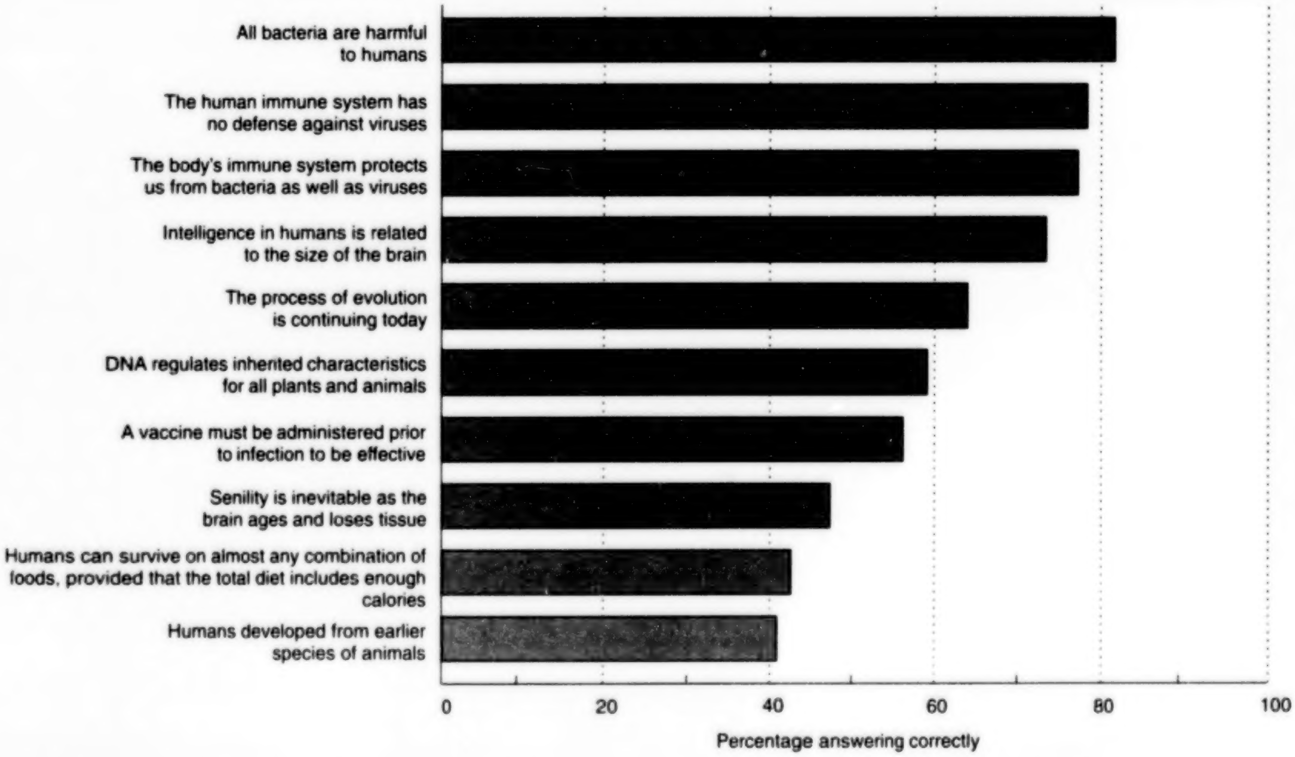
When asked a series of true-false questions about environmental issues, 73 percent of adults agreed that a hole in the ozone layer would cause skin cancer, and 89 percent agreed that acid rain would damage forests. Forty-five percent agreed that the greenhouse effect could raise the level of the oceans. But only 16 percent recognized that car exhaust fumes do not contribute to the acid rain problem.

These results point to a high level of public concern about the environment, albeit with certain significant misunderstandings about basic terms and concepts. Acid rain appears to be seen as a negative phenomenon associated with pollution, but it is poorly understood. There is a reasonably high level of awareness of the health dangers entailed by a thinning of the ozone layer, but there is less understanding of its causes or location.

Understanding of the Scientific Approach

Several *Science and Engineering Indicators* studies have included items concerning the understanding of the scientific process. Both the 1992 *Science and Engineering Indicators* study and the 1993 NIH-NSF study included questions probing knowledge in this area. Each respondent was asked to define the meaning of a scientific study; these open-ended responses were coded independently.

Figure 7-18.
Knowledge of biomedical terms and concepts: 1993



NOTE: See appendix table for exact wordings of statements.

See appendix table 7-23.

Science & Engineering Indicator – 1993

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[9] "Correct" in this case refers to the ability to describe correctly the roles of chlorofluorocarbons (CFCs) or chlorine atoms in the process of creating the hole, or the ability to identify the technologies—aerosol sprays, refrigerants, and styrofoam manufacturing—that release most of the CFCs.

Responses that characterized a scientific study as building theory, seeking to falsify or test hypotheses, doing experimental studies, or engage in careful comparative study were classified as correct. Responses that characterized science only in terms of measurement were classified as incorrect, as were answers like "what scientists do in their laboratories." Using this coding scheme, about one in five American adults was able to provide an acceptable definition of a scientific study (Miller, 1991 and Miller and Pifer, 1993b).

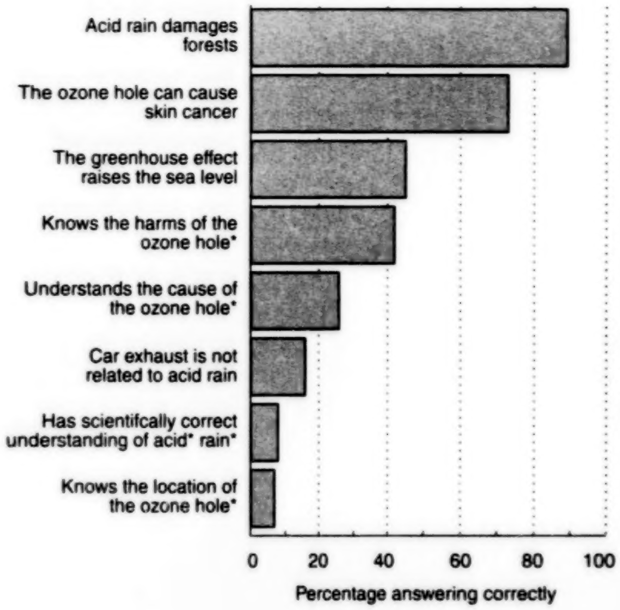
In the 1993 NIH study, each respondent was presented with this problem:

> "Two scientists want to know if a certain drug is effective against high blood pressure. The first scientist wants to give the drug to 1,000 people with high blood pressure and see how many of them experience lower blood pressure levels. The second scientist wants to give the drug to 500 people with high blood pressure, and not give the drug to another 500 people with high blood pressure, and see how many in both groups experience lower blood pressure levels. Which is the better way to test this drug?"

Seventy-six percent of the respondents said that the second approach was the best. On the surface, this would suggest that most people understand the concept of control groups. To explore the level of understanding behind this choice, each respondent was asked to explain, in an open-ended format, why their choice was the better one. In this context, only 36 percent of the respondents in the study were able to describe the use of a control group and explain the reasons for this choice. An additional 13 percent who had selected the two-group choice did not provide any reason for the choice. And 24 percent who had selected the two-group study provided incorrect explanations. Eight percent of the respondents indicated that they selected the single group because they thought that 1,000 cases would be better than 500, and 4 percent rejected the control group choice because they did not want to deny the medicine to persons with high blood pressure.[10]

The results of these two questions indicate that the public's understanding of the scientific process is complex and difficult to measure. Closed-ended questions may tend to overestimate the real level of understanding, but open-ended questions pose different problems in the probing and coding of the responses. Although more work is needed in this area, evidently not more than a third of American adults have a minimal understanding of scientific processes.

Figure 7-19.
Knowledge of environmental terms and concepts: 1992



*Responses were collected in an open-ended format in the telephone interview.

See appendix tables 7-24, 7-25, and 7-26.

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Youth Understanding and Attitudes

Tomorrow's adults are today's elementary and secondary school students. Indepth analyses point to serious and continuing problems in the achievement levels attained by U.S. students in science and mathematics.[11] The strong positive relationship observed in the *Science & Engineering Indicators* data between the number of high school and college science and mathematics courses taken and adult understanding of scientific terms and concepts demonstrates the important link between school science achievement and adult understanding of science.

The Longitudinal Study of American Youth (LSAY) which provides information on high school seniors has been monitoring the development of middle school and high school student attitudes toward and achievement in science and mathematics over the last 7 years.[12] To parallel the adult *Science and Enginering Indicators* studies,

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[10] Note that current medical research would most likely focus on comparing two studies of available therapies and new therapies and would be unlikely to include a control group in which patients with an illness or condition received no therapy at all. However, this question was constructed to measure the public's understanding of a control group, not their understanding of control study design.

[11] See chapter 1, "Student Achievement," for more detail; also see Koretz (1991) and Research, Evaluation, and Dissemination Division (1993), chapter 1.

[12] LSAY is a two-strand longitudinal study of a national sample of public middle and high school students. Beginning in fall 1987, approximately 3,000 7th grade and 3,000 10th grade students have been monitored regarding their attitudes, achievement, and career plans vis-à-vis science and mathematics. In addition to student achievement tests and attitudinal questionnaires, information has been collected each year from each student's mathematics and science teachers and from one parent. LSAY is supported by an NSF grant.

Environmental Interest and Knowledge in the European Community and the United States

Nearly 60 percent of the citizens of the European Community and the United States reported that they were very interested in environmental issues, in parallel national studies conducted in late 1992. (See text table 7-3.) Additionally, about a quarter of both Europeans and Americans indicated that they felt "very well-informed" about these issues.

When asked to rate their level of understanding of several important environmental concepts, a higher proportion of European Community adults were willing to classify themselves as having a clear understanding than were Americans. For example, regarding the hole in the ozone layer, 44 percent of European adults, compared to 30 percent of American adults, reported that they had a clear understanding of the problem. Similar patterns were found for the level of understanding of acid rain, air pollution, global warming, and the greenhouse effect.

Looking at the more objective measures of environmental knowledge available for Europe and the United States, a similar pattern was found. A higher percentage of European respondents provided correct responses to most items than did the Americans. Over 30 percent of European adults, for example, knew the location of the most serious thinning of the ozone layer, compared to 17 percent of American adults. Similarly, 81 percent of European adults recognized that the thinning of the ozone layer can cause skin cancer, compared to 73 percent of Americans. The margin of difference between the Europeans and the Americans is not large, but it is consistent across environmental knowledge questions. These differences may provide an opportunity to study more carefully the origins of public interest in public policy issues, the perception of knowledgeability, and the acquisition of relevant scientific and technical information.

Text table 7–3.
Adult interest in and knowledge about environmental issues and concepts: 1992

	European Community	United States
	Percent	
Interest in environmental issues		
Very interested	56	59
Moderately interested	38	36
Not very interested	6	5
Informed about environmental issues		
Very well-informed	25	29
Moderately well-informed	60	56
Poorly informed	14	15
Subjective environmental knowledge		
Acid rain	40	32
Air pollution	57	52
Global warming	37	27
The hole in the ozone layer	44	30
The greenhouse effect	40	27
Objective environmental knowledge		
Location of hole in ozone layer	31	17
Hole in ozone layer can cause skin cancer	81	73
Greenhouse effect can reduce deserts	47	32
Greenhouse effect can raise sea level	59	45
Acid rain can cause damage to forests	90	89
Car exhausts have nothing to do with acid rain	20	16
N =	12,800	2,001

NOTES: There were slight variations in the wording of the questions between the European Community and U.S. samples. The items measuring subjective and objective knowledge were asked of a random half of the U.S. sample (N = 1,004). Percentages for the subjective items represent those reporting "clear understanding." Percentages for the objective items represent percent correct.

SOURCE: J.D. Miller and L.K. Pifer, 1993a.

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high school seniors in 1990 and 1993 were asked a set of attitude and knowledge items identical to those asked of adults.

Understanding of Selected Terms and Concepts

In both 1990 and 1993, LSAY gauged seniors' understanding of common scientific concepts such as evolution, continental drift, and the nature of scientific theory. (See figure 7-20.) In almost every area, the performance of the 1993 high school seniors was lower than that of the 1990 seniors.

In 1993, 75 percent of the seniors agreed that smoking causes serious health problems—a relatively low proportion, given the extensive media and societal focus on this issue. In fact, a full quarter of the students surveyed had some doubts about the health hazards of smoking.

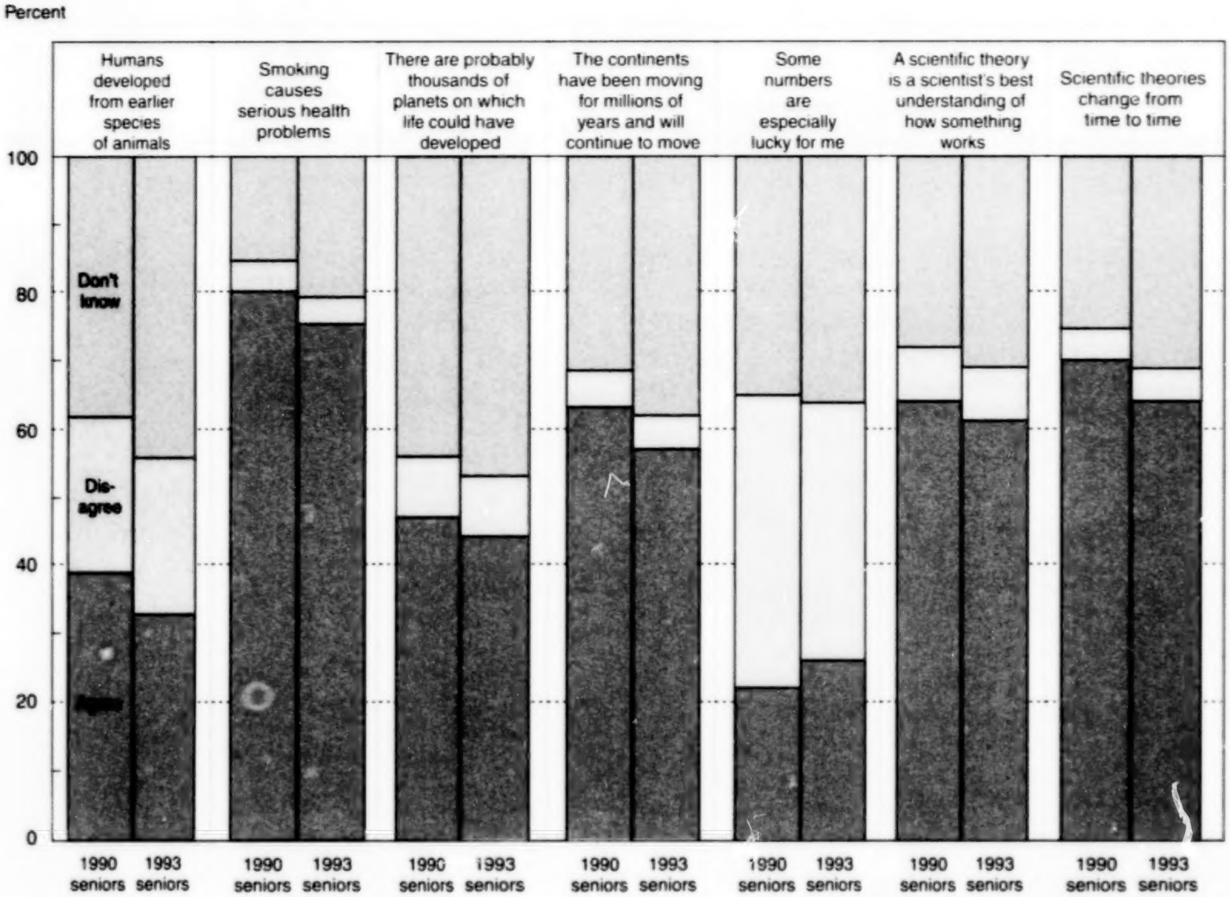
Responses to three other statements reveal a high degree of student misunderstanding or uncertainty regarding generally accepted scientific constructs.

- Only a third of 1993 high school seniors accepted the concept of evolution; almost a quarter did not.
- Only 44 percent agreed that life could have developed on other planets.
- Only 37 percent rejected the idea of lucky numbers.

Students exhibited much uncertainty in their responses. About a third of the 1993 respondents answered "don't know" to six of the seven statements.

On the other hand, the results indicate that slightly more than 60 percent of high school seniors in 1990 and 1993 recognized that a scientific theory reflects scientists' best understanding of how something works; and

Figure 7-20.
Scientific understanding of high school seniors



NOTE: See appendix table for exact wordings of statements.
See appendix table 7-27.

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about the same proportion of 1990 and 1993 seniors understood that scientific theories will change from time to time. These results suggest that a larger proportion of recent high school graduates than of comparable samples of U.S. adults understand the scientific process.

Attitudes Toward S&T[13]

While high school seniors in 1990 and 1993 displayed a generally positive attitude toward science and technology, there were signs of reservation and wariness. Sixty-two percent of 1993 seniors agreed with the statement that "scientific invention is largely responsible for our standard of living in the United States." In contrast, 85 percent of the adult population agreed that "science and technology are making our lives healthier, easier, and more comfortable."[14] (See figure 7-21 and appendix table 7-13.) In both 1990 and 1993, only 3 percent of students disagreed that S&T had made a major contribution to the standard of living, but there was an increased level of uncertainty in their responses.

There is, however, no evidence of a growth in negative attitudes toward S&T among high school students. Only a quarter of public high school seniors in 1990 and 1993 thought that "science is making our way of life change too fast," and about the same proportion was willing to agree that "because of their knowledge, scientific researchers have a power that makes them dangerous." Fewer than 10 percent of public high school seniors in 1990 and 1993 overtly disagreed that "scientific researchers are dedicated people who work for the good of humanity." (See figure 7-21.)

Most (52 percent) high school seniors were uncertain about the potential impact of computers and automation on jobs, and the balance was almost evenly divided between optimists and pessimists. Among 1993 seniors, 26 percent indicated that they expected computers and factory automation to *create* more jobs than they would eliminate, while 22 percent disagreed with that idea. The

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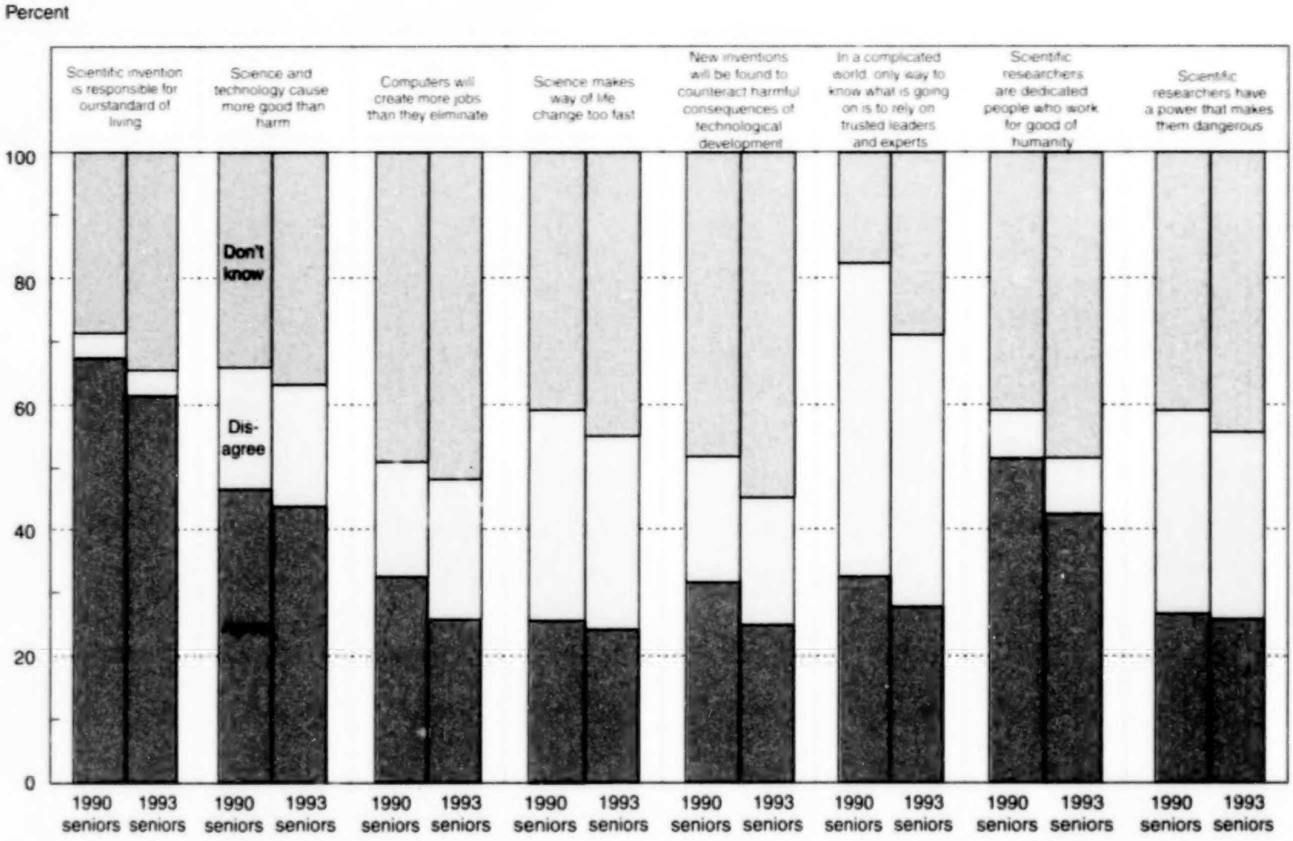
[13] The attitudinal portion of the LSAY study included some attitude items that had been previously used in national adult studies in the United States and other countries. The wording is identical for most items; there are minor differences on some items.

[14] Note that although the LSAY and adult questions are not identical, they both provide information on views of the role of S&T regarding general well-being.

Figure 7-21.
Attitudes toward science and technology among high school seniors



See appendix table 7-28. *Science & Engineering Indicators – 1993*

majority (55 percent) of U.S. adults surveyed on this issue in the 1992 *Science & Engineering Indicators* study expected computers and automation to ***eliminate*** more jobs than they would create; about 40 percent took the view that more jobs would be created. Among adults, however, only 6 percent responded that they did not know what the potential impact would be.

Parallel to these slightly heightened reservations about the impact of computers and automation, the LSAY results point to a modest decline in the belief that there will be a technological solution to almost any future problem. A third of 1990 public school seniors agreed that "new inventions will always be found to counteract any harmful consequences of technological development," while 70 percent overtly disagreed with the statement and 48 percent were uncertain. Three years later, only 25 percent of 1993 seniors agreed with this statement, and 55 percent were uncertain.

When asked to assess the balance of benefits and harms from science and technology, 44 percent of 1993 high school seniors thought that S&T caused more good than harm, but 19 percent of seniors in both years disagreed with that view. In contrast, 73 percent of adults in 1992 thought the benefits of scientific research were greater than any harms, with only 17 percent taking the opposing view.[15]

Looking at the broader sets of results in the LSAY and adult studies, it is apparent that a substantially larger proportion of students have not yet developed an attitude toward S&T. As these students progress into work and/or college, they will acquire more experiences and information, and it is likely that the proportion holding attitudes on these issues will continue to increase during their young adult years. On the other hand, the increased level of uncertainty between the 1990 and 1993 seniors cannot be explained developmentally.

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[15] There are minor differences in the wording and data collection for this item between the adult and student samples. In LSAY, the students were asked on a printed questionnaire to strongly agree, agree, disagree, strongly disagree, or indicate that they were uncertain about the statement "Overall, science and technology have caused more good than harm." The adult data were collected by telephone interview (wording of the adult question is contained in appendix table 7-18). In the adult interview, a response of about equal or uncertain was accepted, but not offered. Even given these differences between the two questions, the magnitude of the differences in student and adult responses cannot be attributed to methodology alone.

Conclusion: The Public Context of Science

On balance, most Americans continue to hold positive views of science and technology, expecting continued advances in health, communication, and other fields. There is a moderately high level of interest in new scientific discoveries and the use of new inventions and technologies, and a very high level of interest in new medical discoveries. The vast majority of Americans continue to have reservations about their understanding of scientific and technical concepts, and objective measurements of their knowledge suggest that these reservations are realistic. About 15 percent of Americans follow S&T issues in the news and try to stay up to date on these matters. These attentive citizens know somewhat more about science and technology and hold even more positive attitudes toward S&T than other citizens. In the context of a specialized political system, this attentive public represents a reasonable core of citizen support.

It appears that citizens interested in S&T are active readers and viewers of news and information on these subjects. At the same time, most citizens expressed a low level of trust in many widely used information sources, especially television. This set of results makes the communication of scientific information problematic—the most widely used information channels are the least trusted. Clearly, this is an area that needs more analysis and examination.

There is some public awareness of the issues of integrity and fraud in scientific work, but the public appears to take a reasonably balanced view of the problem. Most citizens think that there are some scientists who falsify results for professional or personal gain, but there is no indication that this is viewed as an especially acute problem. Responses indicate that confidence in the leadership of the scientific community has increased over the last few years, and in fact, this confidence level is one of the highest for professional groups in American society.

Analyses of the graduating high school classes of 1990 and 1993 point to deficiencies concerning both substantive knowledge about science and understanding of science and technology in society. These recent high school graduates demonstrated more reservations about the future impact of S&T than the present generation of American adults. More than overtly inaccurate information, there was a pervasive absence of any information at all on numerous subjects. As noted elsewhere, the available information concerning student attitudes and student understanding of science and mathematics points to a need for the continuation of present efforts to reform and improve the school experience in these areas.

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Student reports of effort expended on the NAEP mathematics test compared to other math tests, by sex, race/ethnicity, and grade: 1992

Student sex and race/ethnicity	Tried much harder		Tried harder		Tried about as hard		Did not try as hard	
	Percentage of students	Average proficiency	Percentage of students	Average proficiency	Percentage of students	Average proficiency	Percentage of students	Average proficiency
Grade 4								
All students	35 (0.6)	214 (0.9)	20 (0.5)	220 (1.4)	35 (0.7)	227 (0.9)	10 (0.5)	205 (2.0)
Male	35 (0.9)	216 (1.1)	20 (0.7)	221 (1.8)	34 (1.0)	228 (1.3)	11 (0.6)	208 (2.2)
Female	35 (0.9)	213 (1.1)	21 (0.7)	219 (1.8)	36 (0.9)	226 (1.1)	8 (0.6)	200 (2.7)
White	33 (0.7)	222 (1.2)	21 (0.6)	227 (1.5)	38 (0.9)	234 (1.0)	8 (0.6)	216 (2.3)
Asian	36 (3.0)	226 (3.6)	20 (3.1)	232 (5.9)	38 (3.2)	237 (3.1)	6 (1.3)	227 (8.2)
Black	41 (1.5)	194 (1.8)	18 (1.4)	191 (2.6)	26 (1.5)	195 (2.3)	15 (1.1)	181 (3.0)
Hispanic	38 (1.8)	200 (2.1)	18 (1.5)	202 (3.6)	32 (1.7)	206 (2.0)	13 (1.1)	190 (2.8)
Native American	37 (4.7)	205 (4.1)	25 (3.9)	206 (5.8)	24 (4.5)	222 (5.6)	14 (2.6)	204 (5.8)
Grade 8								
All students	12 (0.5)	246 (1.5)	18 (0.6)	259 (1.2)	49 (0.8)	276 (1.0)	20 (0.7)	269 (1.4)
Male	13 (0.8)	246 (2.0)	17 (1.0)	258 (1.7)	47 (1.1)	276 (1.4)	23 (0.8)	269 (1.9)
Female	11 (0.7)	246 (2.0)	19 (0.9)	259 (1.8)	52 (0.8)	276 (1.0)	18 (0.9)	268 (2.0)
White	9 (0.5)	256 (1.7)	16 (0.6)	271 (1.4)	54 (1.0)	283 (1.1)	21 (0.9)	277 (1.5)
Asian	8 (1.8)	260 (8.2)	19 (3.5)	268 (5.6)	52 (4.0)	296 (5.7)	22 (1.8)	300 (4.9)
Black	22 (1.7)	231 (2.5)	24 (1.5)	231 (2.2)	37 (1.8)	246 (2.0)	18 (1.5)	236 (2.4)
Hispanic	20 (1.8)	237 (2.6)	21 (1.4)	238 (2.1)	40 (1.7)	254 (2.0)	18 (1.4)	249 (3.8)
Native American	12 (3.0)	240 (3.4)	19 (4.3)	251 (6.8)	44 (4.3)	260 (4.8)	26 (3.8)	254 (5.1)
Grade 12								
All students	4 (0.2)	274 (2.6)	7 (0.4)	280 (1.8)	44 (1.0)	302 (1.0)	45 (0.9)	301 (1.1)
Male	4 (0.4)	278 (3.6)	7 (0.6)	284 (2.6)	41 (1.2)	304 (1.2)	47 (1.2)	303 (1.4)
Female	3 (0.3)	269 (3.5)	7 (0.5)	277 (2.1)	47 (1.1)	301 (1.2)	43 (1.1)	298 (1.3)
White	3 (0.3)	283 (3.7)	6 (0.4)	289 (2.5)	46 (1.1)	308 (1.0)	45 (1.1)	306 (1.2)
Asian	4 (1.9)	288 (8.9)	6 (1.7)	292 (8.4)	42 (4.1)	316 (3.6)	48 (4.3)	321 (4.2)
Black	5 (0.7)	266 (3.4)	9 (1.0)	262 (3.1)	39 (1.9)	279 (2.2)	47 (2.5)	276 (2.2)
Hispanic	6 (1.4)	250 (6.6)	14 (1.5)	272 (4.5)	43 (4.0)	288 (2.5)	38 (3.4)	287 (2.6)
Native American	10 (8.0)	264 (23.6)	12 (5.0)	267 (7.2)	42 (6.1)	285 (9.8)	36 (9.1)	289 (17.2)

NAEP = National Assessment of Educational Progress

NOTES: Students were asked how hard they tried on the NAEP mathematics test compared with other mathematics test they had taken that year in school. Standard errors are shown in parentheses.

SOURCE: National Center for Education Statistics, *Data Compendium for the NAEP 1992. Mathematics Assessment of the Nation and the States* (Washington, DC: Government Printing Office, 1993).

See figure 1–1.

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Appendix table 1–2.

Student reports of the importance of their performance on the NAEP methematics test, by sex, race/ethnicity, and grade: 1992

Student sex and race/ethnicity	Very important		Important		Somewhat important		Not very important	
	Percentage of students	Average proficiency	Percentage of students	Average proficiency	Percentage of students	Average proficiency	Percentage of students	Average proficiency
				Grade 4				
All students	66 (0.9)	217 (0.9)	23 (0.7)	225 (1.0)	7 (0.4)	222 (1.9)	4 (0.4)	213 (3.1)
Male	64 (1.1)	218 (0.9)	23 (0.9)	226 (1.5)	7 (0.5)	221 (2.3)	5 (0.6)	218 (3.5)
Female	67 (1.1)	215 (1.1)	23 (0.8)	224 (1.5)	6 (0.6)	222 (2.4)	3 (0.3)	204 (4.9)
White	63 (1.9)	226 (1.0)	26 (0.8)	230 (1.1)	8 (0.5)	228 (1.8)	4 (0.4)	224 (3.3)
Asian	65 (3.5)	228 (3.3)	24 (2.7)	239 (2.7)	8 (1.9)	245 (8.8)	4 (0.9)	219 (7.9)
Black	77 (1.2)	192 (1.4)	14 (1.0)	196 (2.7)	5 (0.7)	193 (5.7)	4 (0.7)	179 (5.9)
Hispanic	68 (1.9)	201 (1.6)	22 (1.4)	205 (2.6)	6 (0.7)	196 (6.1)	4 (0.8)	193 (6.5)
Native American	69 (4.3)	208 (3.6)	19 (4.5)	213 (8.0)	6 (2.1)	205 (8.9)	6 (1.5)	220 (9.0)
				Grade 8				
All students	26 (0.8)	261 (1.2)	34 (0.9)	270 (1.2)	27 (0.6)	271 (1.3)	13 (0.6)	270 (1.6)
Male	26 (0.9)	263 (1.7)	31 (1.0)	269 (1.6)	27 (0.6)	270 (1.5)	16 (0.6)	269 (2.0)
Female	26 (1.0)	259 (1.4)	37 (1.2)	271 (1.5)	27 (1.1)	271 (1.9)	10 (0.7)	272 (2.6)
White	22 (0.8)	275 (1.5)	34 (1.2)	279 (1.2)	30 (0.8)	277 (1.5)	14 (0.7)	277 (1.8)
Asian	23 (2.6)	282 (8.4)	35 (4.2)	293 (9.6)	27 (3.4)	286 (4.1)	15 (2.4)	290 (5.2)
Black	39 (2.5)	234 (1.8)	33 (1.9)	239 (2.1)	19 (1.3)	241 (2.4)	9 (1.2)	237 (4.6)
Hispanic	35 (2.2)	242 (1.9)	33 (1.6)	248 (1.6)	22 (2.0)	251 (2.5)	10 (1.3)	246 (5.0)
Native American	21 (3.8)	258 (6.0)	40 (3.7)	258 (4.2)	20 (2.9)	244 (5.2)	19 (3.0)	254 (6.6)
				Grade 12				
All students	9 (0.5)	292 (1.7)	25 (0.7)	298 (1.3)	36 (0.7)	300 (1.0)	31 (0.9)	300 (1.2)
Male	9 (0.7)	295 (2.3)	23 (1.0)	300 (1.9)	33 (1.0)	302 (1.4)	35 (1.1)	302 (1.5)
Female	8 (0.6)	288 (2.3)	26 (0.9)	297 (1.8)	38 (1.0)	299 (1.1)	27 (1.1)	298 (1.6)
White	6 (0.4)	305 (2.5)	23 (0.7)	307 (1.5)	37 (0.8)	306 (1.0)	34 (1.0)	303 (1.3)
Asian	15 (2.2)	304 (4.9)	24 (3.1)	317 (6.7)	31 (3.1)	313 (5.1)	30 (3.9)	324 (3.9)
Black	15 (1.4)	275 (3.2)	27 (1.9)	275 (2.3)	36 (2.2)	273 (2.3)	22 (1.7)	278 (3.1)
Hispanic	16 (3.3)	274 (6.0)	34 (2.3)	279 (3.3)	30 (1.8)	290 (2.4)	19 (4.1)	287 (3.6)
Native American	11 (7.7)	267 (16.3)	29 (6.8)	283 (10.0)	28 (9.5)	293 (6.7)	32 (6.6)	276 (18.5)

NAEP = National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

SOURCE: National Center for Education Statistics, *Data Compendium for the NAEP 1992, Mathematics Assessment of the Nation and the States* (Washington, DC: Government Printing Office,1993).

See figure 1–1.

Science & Engineering Indicators – 1993

Appendix table 1–3.

Average scores by percentile for the NAEP mathematics test, by sex and race/ethnicity for age 9: 1978–90

Percentile	1978		1982		1986		1990	
All students								
5th	157.1	(1.0)	159.3	(1.8)	163.0	(1.3)	173.3	(2.6)
10th	171.1	(1.2)	173.2	(1.8)	176.7	(1.5)	185.8	(2.2)
25th	194.6	(1.0)	196.0	(1.1)	199.0	(1.6)	207.8	(1.3)
50th	220.1	(1.0)	220.4	(1.2)	223.3	(1.1)	231.1	(0.9)
75th	243.7	(0.9)	243.3	(1.4)	245.6	(1.2)	252.5	(0.7)
90th	264.0	(1.2)	262.7	(1.0)	264.2	(1.3)	271.0	(1.0)
95th	275.7	(1.2)	273.8	(1.3)	275.5	(1.2)	282.1	(1.3)
Males								
5th	154.9	(2.3)	156.4	(2.1)	162.7	(2.0)	171.8	(2.5)
10th	169.0	(1.3)	170.2	(1.4)	176.1	(1.7)	184.6	(2.1)
25th	192.8	(1.0)	193.0	(1.5)	198.6	1.6	206.7	(1.2)
50th	218.4	(0.9)	218.6	(1.7)	223.0	(1.0)	230.4	(1.0)
75th	243.0	(1.1)	242.3	(1.6)	245.7	(1.6)	252.4	(0.8)
90th	263.8	(1.2)	262.2	(1.2)	265.1	(1.9)	271.6	(1.8)
95th	275.2	(1.1)	273.6	(1.9)	276.4	(2.1)	282.8	(1.7)
Females								
5th	159.4	(1.3)	162.8	(1.7)	163.5	(2.3)	174.5	(2.8)
10th	173.1	(2.0)	176.6	(1.6)	177.5	(2.6)	187.0	(2.7)
25th	196.4	(1.2)	198.9	(1.8)	199.0	(1.8)	208.9	(1.3)
50th	221.5	(1.0)	222.2	(1.1)	223.5	(1.1)	231.8	(1.0)
75th	244.3	(1.5)	244.2	(1.4)	245.5	(1.5)	252.7	(1.0)
90th	264.2	(1.4)	263.1	(1.0)	263.3	(1.6)	270.4	(1.3)
95th	276.1	(1.8)	273.9	(1.7)	274.2	(2.0)	281.4	(1.1)
Whites								
5th	166.3	(1.5)	168.1	(1.4)	170.6	(2.4)	181.8	(2.4)
10th	179.4	(1.5)	180.8	(1.7)	183.9	(1.7)	194.0	(1.6)
25th	201.4	(1.1)	201.9	(1.3)	205.3	(1.1)	214.6	(0.9)
50th	225.1	(1.0)	225.3	(1.4)	228.3	(1.1)	214.6	(0.9)
75th	247.7	(0.8)	246.8	(0.9)	249.6	(0.8)	256.4	(0.6)
90th	267.0	(1.1)	265.3	(1.0)	267.4	(1.2)	274.5	(0.8)
95th	278.4	(1.7)	276.0	(1.3)	278.2	(1.8)	284.8	(2.1)
Blacks								
5th	133.7	(1.9)	136.7	(2.5)	146.2	(3.2)	156.0	(1.7)
10th	147.0	(1.7)	150.4	(2.3)	158.4	(4.9)	167.1	(3.7)
25th	169.3	(1.9)	172.5	(2.0)	180.5	(4.1)	186.0	(4.1)
50th	193.0	(1.1)	196.6	(2.0)	202.9	(1.6)	208.4	(3.1)
75th	216.4	(1.6)	218.2	(2.0)	223.6	(2.0)	231.4	(2.1)
90th	236.1	(1.6)	235.7	(2.5)	241.2	(1.7)	248.9	(2.9)
95th	247.5	(1.4)	247.9	(2.8)	251.3	(1.3)	258.9	(4.3)
Hispanics								
5th	144.4	(5.4)	148.1	(2.8)	154.8	(3.7)	161.8	(3.4)
10th	156.3	(3.7)	160.8	(3.2)	163.8	(1.8)	173.4	(1.4)
25th	178.7	(3.2)	181.3	(2.3)	184.5	(3.2)	193.1	(3.6)
50th	204.3	(3.0)	205.2	(1.6)	205.3	(2.4)	216.2	(4.1)
75th	227.2	(2.5)	226.5	(2.0)	226.0	(3.8)	251.7	(3.4)
90th	249.5	(4.0)	246.4	(3.4)	244.8	(3.8)	251.7	(3.4)
95th	259.6	(4.6)	256.6	(2.9)	254.4	(4.6)	262.2	(3.5)

NAEP: National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

See figure 1-2.

Appendix table 1–4.

Average scores by percentile for the NAEP mathematics test, by sex and race/ethnicity for age 13: 1978–90

Percentile	1978		1982		1986		1990	
All students								
5th	198.2	(1.6)	212.4	(2.7)	218.3	(1.8)	217.6	(2.2)
10th	213.3	(1.5)	225.3	(1.6)	230.0	(1.4)	230.2	(1.4)
25th	238.1	(1.3)	246.2	(1.2)	248.3	(1.8)	249.8	(0.9)
50th	265.2	(1.1)	269.5	(1.0)	268.7	(1.3)	270.9	(1.0)
75th	291.1	(1.1)	291.6	(1.1)	289.6	(1.3)	291.7	(1.0)
90th	313.4	(1.2)	310.8	(1.2)	309.2	(1.5)	309.9	(1.0)
95th	326.6	(1.3)	322.2	(1.2)	320.5	(2.2)	320.1	(1.6)
Males								
5th	195.8	(1.4)	211.5	(2.2)	218.0	(1.8)	215.5	(2.1)
10th	211.4	(1.4)	224.3	(2.0)	229.5	(1.7)	228.6	(2.0)
25th	236.7	(1.4)	246.1	(1.5)	248.9	(2.3)	250.2	(1.7)
50th	264.8	(1.4)	270.2	(1.2)	270.0	(1.6)	272.0	(1.0)
75th	291.5	(1.5)	293.3	(1.2)	291.4	(1.6)	293.1	(1.2)
90th	314.4	(1.7)	312.5	(1.5)	310.8	(1.5)	312.4	(1.4)
95th	327.5	(1.5)	324.1	(1.3)	322.0	(2.6)	323.1	(1.9)
Females								
5th	200.9	(2.6)	213.5	(1.5)	218.5	(3.2)	220.4	(2.3)
10th	215.0	(1.6)	226.2	(1.4)	230.6	(2.0)	231.4	(1.2)
25th	239.4	(1.4)	246.3	(1.1)	247.8	(1.5)	249.5	(1.1)
50th	265.7	(1.2)	268.8	(0.9)	267.4	1.7	269.9	(1.2)
75th	290.7	(1.0)	290.1	(1.1)	287.8	(1.7)	290.3	(1.3)
90th	312.4	(1.4)	308.8	(1.5)	307.2	2.8	307.7	(1.5)
95th	325.6	(1.2)	320.1	(2.0)	318.5	(2.4)	317.3	(0.8)
Whites								
5th	211.9	(1.4)	223.0	(1.6)	225.7	(1.5)	228.2	(1.5)
10th	225.5	(1.4)	234.4	(1.2)	236.5	(1.3)	239.3	(1.0)
25th	247.6	(0.9)	253.5	(1.1)	254.1	(1.4)	257.3	(1.1)
50th	272.2	(1.0)	274.9	(0.9)	273.3	(1.0)	276.6	(1.0)
75th	296.0	(0.7)	295.5	(1.0)	293.2	(1.3)	296.0	(1.1)
90th	317.1	(1.2)	313.8	(1.4)	312.1	(2.2)	313.2	(1.3)
95th	329.6	(1.3)	324.8	(1.4)	322.9	(1.8)	322.9	(1.6)
Blacks								
5th	170.2	(1.9)	201.7	(4.5)	201.7	(4.5)	201.6	(5.4)
10th	184.1	(2.6)	200.2	(3.7)	213.2	(2.3)	211.8	(2.2)
25th	205.5	(1.9)	219.3	(1.8)	230.7	(2.2)	229.9	(3.0)
50th	229.0	(2.2)	241.0	(1.9)	249.3	(2.3)	249.4	(2.0)
75th	254.1	(2.2)	260.9	(1.4)	266.9	(1.5)	267.8	(2.9)
90th	276.4	(2.4)	279.7	(2.2)	284.4	(3.7)	285.3	(2.8)
95th	288.4	(3.9)	291.1	(1.7)	296.4	(4.3)	296.2	(4.1)
Hispanics								
5th	180.2	(1.8)	202.3	(2.2)	205.9	(3.6)	206.2	(3.7)
10th	192.5	(2.2)	213.5	(2.6)	216.2	(3.8)	216.4	(3.1)
25th	214.3	(1.8)	230.7	(1.9)	235.5	(2.7)	234.3	(2.2)
50th	237.4	(2.0)	251.9	(1.4)	254.3	(3.4)	255.1	(1.9)
75th	261.9	(3.2)	273.7	(1.4)	254.3	(3.4)	275.2	(3.5)
90th	283.7	(3.4)	292.8	(2.4)	291.7	(3.1)	292.2	(2.9)
95th	296.3	(3.1)	304.1	(2.9)	301.2	(1.9)	303.3	(3.3)

NAEP = National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

See figure 1–2.

Appendix table 1–5.
Average scores by percentile for the NAEP mathematics test, by sex and race/ethnicity for age 17: 1978–90

Percentile	1978		1982		1986		1990	
All students								
5th	241.3	(1.3)	244.9	(1.1)	251.7	(1.2)	253.4	(1.0)
10th	254.2	(1.1)	255.9	(1.0)	262.7	(1.0)	264.0	(1.1)
25th	276.4	(1.2)	275.8	(1.3)	280.7	(0.6)	282.5	(1.0)
50th	301.4	(1.1)	298.8	(1.0)	301.4	(1.3)	304.9	(1.1)
75th	325.4	(1.0)	321.5	(0.8)	323.1	(1.9)	326.5	(1.2)
90th	344.7	(0.8)	340.6	(0.9)	343.0	(1.3)	344.5	(1.3)
95th	355.7	(0.9)	351.2	(1.1)	354.0	(1.1)	355.5	(2.2)
Males								
5th	243.8	(1.2)	247.0	(1.3)	252.7	(3.0)	252.8	(3.0)
10th	257.0	(1.2)	257.9	(1.2)	264.1	(1.2)	263.9	(1.2)
25th	278.9	(1.2)	278.1	(1.1)	282.3	(1.8)	283.7	(1.3)
50th	304.8	(1.3)	301.8	(1.6)	303.9	(1.2)	306.4	(1.6)
75th	329.5	(1.1)	325.1	(1.2)	327.8	(2.1)	329.3	(1.1)
90th	349.2	(1.0)	344.4	(1.1)	346.7	(1.6)	347.8	(1.4)
95th	360.1	(1.0)	354.4	(1.8)	357.5	(1.7)	358.5	(1.3)
Females								
5th	239.3	(1.3)	242.8	(1.6)	250.3	(2.8)	253.9	(1.9)
10th	252.2	(1.0)	254.1	(1.2)	261.2	(1.4)	264.0	(1.5)
25th	274.3	(1.3)	273.7	(1.2)	279.3	(1.3)	303.7	(1.7)
50th	298.3	(1.1)	296.1	(1.2)	299.1	(1.3)	303.7	(1.7)
75th	321.5	(1.0)	317.7	(0.8)	319.8	(1.7)	324.1	(1.2)
90th	340.3	(1.4)	336.7	(1.7)	338.2	(2.2)	341.4	(1.6)
95th	350.4	(1.5)	347.2	(1.5)	349.3	(1.9)	351.8	(2.2)
Whites								
5th	251.9	(0.6)	253.3	(1.1)	261.2	(1.6)	260.2	(1.3)
10th	263.3	(1.3)	263.8	(1.1)	270.5	(1.3)	270.5	(1.5)
25th	283.5	(1.0)	282.3	(1.1)	286.9	(1.2)	288.8	(1.5)
50th	306.6	(1.0)	303.9	(1.2)	306.8	(1.3)	310.1	(1.3)
75th	328.9	(0.8)	325.1	(0.9)	327.8	(1.7)	330.1	(1.2)
90th	347.3	(0.7)	343.4	(1.1)	346.1	(1.3)	347.2	(1.0)
95th	357.8	(0.7)	353.4	(1.5)	356.0	(1.4)	357.1	(1.3)
Blacks								
5th	217.2	(2.0)	225.1	(1.4)	236.7	(3.9)	245.4	(4.4)
10th	227.8	(1.7)	234.5	(1.7)	244.3	(4.2)	253.5	(3.5)
25th	245.7	(1.2)	251.4	(1.6)	259.9	(1.5)	268.7	(1.8)
50th	267.7	(1.6)	271.2	(1.4)	278.6	(3.9)	287.1	(2.5)
75th	290.5	(2.2)	291.2	(1.7)	296.1	(2.5)	307.1	(5.3)
90th	310.3	(2.1)	310.8	(1.7)	312.0	(7.4)	325.7	(5.8)
95th	320.7	(2.5)	321.3	(2.2)	324.8	(4.1)	337.7	(4.2)
Hispanics								
5th	224.1	(4.4)	232.0	(1.7)	236.3	(5.3)	229.1	(5.4)
10th	234.0	(2.9)	240.7	(3.2)	248.5	(4.5)	242.2	(8.1)
25th	253.4	(1.8)	255.8	(2.4)	264.7	(2.8)	263.8	(6.8)
50th	275.1	(3.6)	275.3	(3.2)	283.1	(2.5)	281.8	(2.4)
75th	298.5	(3.9)	297.1	(2.6)	301.2	(4.2)	304.0	(4.4)
90th	319.5	(3.6)	314.9	(2.6)	318.6	(2.3)	325.1	(3.6)
95th	332.0	(0.9)	326.7	(4.4)	329.3	(7.3)	336.3	(8.6)

NAEP = National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

See figure 1–2.

Appendix table 1–6.

Average scores by percentile for the NAEP science test, by sex and race/ethnicity for age 9: 1977–90

Percentile	1977		1982		1986		1990	
All students								
5th	143.8	(2.3)	150.9	(1.3)	155.0	(1.3)	159.8	(1.3)
10th	160.9	(2.1)	166.8	(2.6)	169.9	(1.8)	176.1	(1.1)
25th	190.1	(1.6)	194.4	(2.2)	195.4	(2.2)	202.0	(1.4)
50th	221.5	(1.1)	221.4	(2.4)	225.1	(1.7)	230.3	(0.9)
75th	251.0	(1.1)	249.0	(2.0)	253.1	(1.7)	256.6	(0.8)
90th	276.5	(1.2)	272.4	(3.9)	276.9	(2.0)	278.8	(1.3)
95th	291.4	(1.2)	286.4	(3.7)	290.9	(1.9)	292.1	(1.4)
Males								
5th	146.8	(2.6)	150.4	(5.5)	158.0	(3.6)	159.6	(2.2)
10th	163.2	(1.9)	166.5	(3.8)	172.9	(1.8)	176.3	(2.3)
25th	191.9	(1.9)	193.5	(4.1)	198.7	(1.8)	202.1	(2.5)
50th	223.6	(1.4)	221.3	(3.6)	227.9	(1.7)	231.6	(1.9)
75th	253.4	(1.4)	250.4	(3.1)	256.1	(1.9)	259.4	(1.0)
90th	279.1	(1.3)	274.7	(4.3)	280.3	(2.0)	283.3	(1.8)
95th	294.2	(1.5)	287.1	(5.3)	294.8	(2.7)	296.3	(2.4)
Females								
5th	141.3	(3.5)	151.2	(6.6)	152.5	(2.5)	159.9	(2.4)
10th	158.5	(2.2)	167.5	(3.1)	166.9	(2.6)	175.8	(2.2)
25th	188.3	(1.4)	195.3	(2.6)	193.2	(1.8)	201.9	(1.2)
50th	219.5	(1.2)	221.4	(3.6)	222.5	(2.0)	229.2	(1.1)
75th	248.6	(1.1)	247.4	(2.4)	250.2	(1.9)	254.0	(1.1)
90th	273.8	(1.6)	270.6	(3.4)	273.3	(1.6)	274.6	(1.9)
95th	288.2	(1.6)	284.4	(3.4)	287.0	(2.6)	287.0	(1.9)
Whites								
5th	163.2	(1.3)	167.0	(3.0)	166.5	(2.3)	176.9	(1.4)
10th	177.6	(1.1)	182.2	(3.1)	181.0	(1.5)	189.9	(1.5)
25th	202.4	(1.1)	203.8	(2.6)	205.5	(1.5)	212.6	(0.8)
50th	229.8	(0.9)	228.6	(2.4)	232.5	(1.6)	238.3	(1.0)
75th	256.9	(0.8)	254.9	(2.0)	258.8	(1.4)	262.3	(1.0)
90th	281.1	(1.1)	277.6	(2.8)	281.7	(1.7)	283.5	(1.4)
95th	295.4	(1.9)	290.8	(4.0)	294.9	(2.5)	295.7	(1.3)
Blacks								
5th	107.0	(3.5)	123.6	(11.0)	132.8	(3.2)	131.3	(4.2)
10th	122.8	(3.4)	136.7	(8.3)	146.9	(3.5)	145.3	(3.8)
25th	146.6	(2.4)	159.2	(4.9)	169.7	(2.6)	169.8	(2.6)
50th	173.8	(2.5)	188.2	(5.0)	195.9	(2.2)	196.3	(2.5)
75th	202.9	(1.8)	214.4	(3.8)	222.6	(1.5)	224.1	(1.7)
90th	229.2	(2.9)	236.4	(4.7)	246.4	(3.7)	246.8	(2.4)
95th	244.1	(2.9)	246.5	(3.3)	259.5	(3.5)	260.0	(5.4)
Hispanics								
5th	125.2	(7.0)	127.3	(9.6)	134.0	(10.1)	146.2	(5.5)
10th	139.8	(3.3)	141.9	(16.8)	148.1	(5.2)	158.5	(4.3)
25th	163.9	(4.3)	161.9	(4.4)	172.6	(3.4)	180.6	(3.7)
50th	191.4	(3.6)	190.8	(4.8)	199.8	(6.7)	206.2	(3.7)
75th	219.0	(3.2)	215.9	(3.4)	225.6	(4.1)	232.7	(4.1)
90th	245.7	(4.9)	236.2	(5.6)	252.1	(5.4)	252.9	(4.4)
95th	261.3	(6.4)	246.0	(7.6)	264.9	(6.7)	266.8	(6.9)

NAEP = National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

See figure 1-3.

Appendix table 1–7.

Average scores by percentile for the NAEP science test, by sex and race/ethnicity for age 13: 1977–90

Percentile	1977		1982		1986		1990	
All students								
5th	173.7	(1.7)	185.2	(2.2)	188.9	(2.2)	191.4	(2.0)
10th	190.6	(1.4)	199.6	(1.8)	203.3	(2.0)	205.9	(1.7)
25th	218.4	(1.4)	224.1	(1.1)	227.2	(1.3)	230.0	(1.5)
50th	248.6	(1.2)	250.9	(1.3)	252.1	(1.8)	256.4	(1.2)
75th	277.5	(0.9)	276.7	(1.5)	276.5	(1.5)	281.1	(0.9)
90th	302.4	(0.9)	299.2	(1.6)	298.2	(2.0)	302.4	(1.1)
95th	316.0	(1.5)	312.8	(1.3)	310.3	(1.6)	315.1	(1.9)
Males								
5th	176.7	(1.9)	190.2	(2.6)	192.3	(4.2)	191.9	(2.5)
10th	193.5	(1.6)	204.4	(1.6)	207.2	(2.5)	207.3	(3.4)
25th	221.5	(1.7)	229.5	(1.7)	231.1	(1.6)	232.9	(1.4)
50th	252.4	(1.5)	256.7	(1.5)	256.9	(2.0)	260.3	(1.4)
75th	281.6	(1.2)	282.6	(1.5)	282.4	(1.4)	285.8	(2.2)
90th	306.5	(1.3)	305.0	(1.7)	303.4	(1.6)	307.4	(1.5)
95th	321.2	(1.5)	318.3	(2.3)	316.2	(2.2)	320.2	(1.2)
Females								
5th	170.8	(1.6)	180.2	(1.9)	186.3	(2.2)	190.6	(2.1)
10th	187.7	(1.8)	195.5	(2.3)	200.5	(2.9)	204.8	(1.5)
25th	215.5	(1.7)	219.7	(1.4)	223.4	(1.5)	227.8	(1.6)
50th	245.0	(1.2)	246.1	(1.7)	248.0	(1.7)	253.1	(1.2)
75th	273.0	(1.5)	271.0	(1.9)	271.0	(1.8)	276.8	(1.6)
90th	297.7	(1.0)	292.8	(1.5)	291.3	(1.7)	296.8	(1.1)
95th	312.1	(2.2)	305.3	(1.8)	304.0	(3.6)	308.6	(1.4)
Whites								
5th	190.8	(0.9)	198.0	(1.7)	203.5	(2.7)	208.6	(1.6)
10th	205.2	(1.2)	210.8	(1.7)	215.8	(1.5)	220.4	(1.2)
25th	229.3	(1.3)	233.2	(1.2)	237.0	(1.9)	241.3	(0.9)
50th	256.3	(0.8)	257.6	(1.3)	259.2	(2.0)	264.5	(1.1)
75th	282.9	(0.7)	281.5	(1.1)	282.3	(1.9)	287.0	(1.7)
90th	306.6	(0.9)	302.7	(1.6)	302.2	(1.9)	307.1	(1.4)
95th	320.8	(1.1)	316.2	(1.7)	313.9	(2.1)	319.4	(1.3)
Blacks								
5th	144.3	(3.2)	160.3	(3.1)	167.8	(1.7)	169.7	(5.5)
10th	157.7	(2.4)	173.0	(3.1)	180.1	(2.2)	181.8	(6.1)
25th	180.5	(2.2)	193.7	(2.4)	198.3	(3.0)	202.3	(3.7)
50th	207.4	(2.5)	216.8	(1.3)	221.2	(2.8)	225.7	(3.0)
75th	234.8	(2.6)	240.7	(2.2)	243.5	(3.6)	249.1	(2.6)
90th	259.5	(3.4)	262.2	(3.5)	264.4	(4.9)	269.0	(4.2)
95th	274.6	(2.7)	274.7	(1.9)	276.8	(2.5)	283.2	(3.7)
Hispanics								
5th	147.1	(3.5)	166.3	(4.9)	171.1	(5.6)	173.7	(4.7)
10th	161.4	(3.0)	179.4	(4.1)	181.3	(4.5)	185.3	(4.5)
25th	185.8	(3.5)	200.7	(3.6)	201.6	(5.5)	205.9	(4.1)
50th	213.3	(2.5)	225.9	(4.4)	225.6	(3.8)	230.9	(3.3)
75th	240.3	(3.5)	249.3	(5.1)	249.8	(3.4)	256.4	(5.1)
90th	265.8	(2.0)	271.2	(5.1)	269.9	(3.5)	280.0	(5.9)
95th	282.1	(4.4)	284.8	(6.1)	283.0	(3.8)	294.2	(2.8)

NAEP = National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

See figure 1–3.

Appendix table 1–8.

Mean student proficiency in the NAEP science test, by sex and race/ethnicity for age 17: 1977–90

Percentile	1977		1982		1986		1990	
All students								
5th	212.6	(1.3)	203.2	(2.2)	211.8	(2.4)	209.9	(2.3)
10th	231.3	(1.4)	221.5	(1.9)	229.5	(2.4)	228.8	(2.0)
25th	260.6	(1.4)	252.5	(2.1)	259.6	(1.9)	260.3	(1.9)
50th	290.8	(1.0)	285.4	(1.0)	290.1	(1.9)	292.2	(1.3)
75th	320.1	(0.9)	315.3	(1.6)	319.4	(1.3)	322.7	(1.4)
90th	246.2	(1.1)	341.5	(1.1)	344.5	(1.9)	348.3	(1.2)
95th	361.5	(1.3)	357.3	(1.4)	359.9	(2.0)	362.9	(1.5)
Males								
5th	219.5	(2.1)	210.3	(2.3)	213.9	(2.8)	210.4	(3.9)
10th	238.2	(1.6)	228.9	(2.7)	231.4	(5.0)	229.5	(2.9)
25th	267.6	(1.5)	261.1	(1.9)	263.5	(3.0)	263.4	(1.3)
50th	298.5	(1.2)	294.3	(0.4)	298.7	(2.8)	297.9	(1.9)
75th	328.1	(1.4)	324.8	(2.0)	327.6	(1.6)	329.9	(1.8)
90th	353.9	(1.4)	350.5	(1.9)	353.4	(2.8)	356.7	(2.3)
95th	368.8	(1.5)	365.3	(1.3)	367.0	(4.6)	372.5	(1.8)
Females								
5th	207.5	(1.6)	198.3	(3.6)	209.8	(3.5)	209.2	(3.7)
10th	226.1	(2.1)	215.5	(2.6)	228.1	(2.0)	228.2	(4.5)
25th	254.5	(1.5)	245.7	(2.1)	256.2	(2.0)	257.7	(2.4)
50th	283.8	(1.2)	277.6	(2.0)	283.7	(1.4)	287.7	(2.0)
75th	311.5	(1.1)	306.2	(1.2)	310.8	(1.8)	316.2	(2.3)
90th	336.3	(1.2)	330.1	(1.0)	333.5	(3.0)	339.6	(2.3)
95th	351.2	(1.5)	345.2	(1.5)	348.3	(3.2)	351.5	(1.6)
Whites								
5th	231.1	(0.9)	223.0	(1.7)	228.3	(2.9)	232.8	(2.3)
10th	246.0	(0.7)	239.1	(1.5)	244.5	(3.1)	249.0	(2.0)
25th	270.3	(0.8)	265.5	(1.5)	271.0	(2.0)	273.4	(1.5)
50th	297.5	(0.7)	293.6	(1.0)	298.7	(1.7)	301.2	(1.2)
75th	325.0	(0.9)	321.2	(1.6)	324.9	(1.3)	329.0	(1.6)
90th	349.9	(1.0)	246.0	(1.3)	348.9	(3.0)	352.3	(1.3)
95th	364.6	(1.4)	360.8	(1.3)	363.5	(2.8)	367.3	(2.0)
Blacks								
5th	172.4	(1.5)	166.0	(3.1)	189.3	(4.8)	182.0	(10.1)
10th	187.3	(1.9)	180.6	(3.5)	201.6	(4.9)	196.6	(3.1)
25th	212.1	(1.4)	206.4	(3.2)	225.0	(4.2)	220.5	(4.3)
50th	240.4	(1.8)	234.7	(3.0)	251.9	(5.9)	251.6	(3.0)
75th	267.9	(2.0)	262.7	(2.2)	279.5	(3.4)	282.9	(5.0)
90th	293.4	(2.5)	288.8	(3.9)	306.0	(4.2)	313.5	(11.3)
95th	309.5	(2.6)	305.4	(1.6)	322.8	(5.8)	329.3	(10.2)
Hispanics								
5th	193.7	(5.2)	178.0	(6.5)	194.4	(9.3)	188.7	(6.2)
10th	208.4	(4.0)	194.2	(7.2)	209.2	(3.8)	203.9	(11.1)
25th	234.3	(3.9)	218.8	(3.3)	232.0	(5.6)	230.6	(3.6)
50th	262.4	(2.4)	248.0	(2.5)	258.9	(5.8)	260.5	(5.7)
75th	289.5	(5.1)	278.4	((3.4)	285.8	(3.6)	292.6	(10.6)
90th	316.9	(4.4)	302.1	(3.4)	309.9	(7.6)	317.4	(5.1)
95th	331.3	(4.4)	320.8	(11.0)	324.4	(6.3)	329.5	(9.1)

NAEP = National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

See figure 1–3.

Appendix table 1–9.
Average student proficiency scores on the NAEP mathematics and science tests, by sex and age: 1970–90

Sex and age	1970		1973		1977/78[1]		1982		1986		1990	
							Mathematics					
All Students												
9 years	NA	NA	219	(0.8)	219	(0.8)	219	(1.1)	222	(1.0)	230	(0.8)
13 years	NA	NA	266	(1.1)	364	(1.1)	269	(1.1)	369	(1.2)	270	(0.9)
17 years	NA	NA	304	(1.1)	300	(1.0)	299	(0.9)	302	(0.9)	305	(0.9)
Male												
9 years	NA	NA	218	(0.7)	217	(0.7)	217	(1.2)	222	(1.1)	229	(0.9)
13 years	NA	NA	265	(1.3)	264	(1.3)	269	(1.4)	270	(1.1)	271	(1.2)
17 years	NA	NA	309	(1.2)	304	(1.0)	302	(1.0)	305	(1.2)	306	(1.1)
Female												
9 years	NA	NA	220	(1.1)	220	(1.0)	221	(1.2)	222	(1.2)	230	(1.1)
13 years	NA	NA	267	(1.1)	265	(1.1)	268	(1.1)	268	(1.5)	270	(0.9)
17 years	NA	NA	301	(1.1)	297	(1.0)	296	(1.0)	299	(1.0)	303	(1.1)
							Science					
All Students												
9 years	225	(1.2)	220	(1.2)	220	(1.2)	221	(1.8)	224	(1.2)	229	(0.8)
13 years	255	(1.1)	250	(1.1)	247	(1.1)	250	(1.3)	251	(1.4)	255	(0.9)
17 years	305	(1.0)	296	(1.0)	290	(1.0)	283	(1.2)	289	(1.4)	290	(1.1)
Male												
9 years	228	(1.3)	223	(1.3)	222	(1.3)	221	(2.3)	227	(1.4)	230	(1.1)
13 years	257	(1.3)	252	(1.3)	251	(1.3)	256	(1.5)	256	(1.6)	259	(1.1)
17 years	314	(1.2)	304	(1.2)	297	(1.2)	292	(1.4)	295	(1.9)	296	(1.3)
Female												
9 years	223	(1.2)	218	(1.2)	218	(1.2)	221	(2.0)	221	(1.4)	227	(1.0)
13 years	253	(1.2)	247	(1.2)	244	(1.2)	245	(1.3)	247	(1.5)	252	(1.1)
17 years	297	(1.1)	288	(1.1)	282	(1.1)	275	(1.3)	282	(1.5)	285	(1.6)

NA = not available; NAEP = National Assessment of Educational Progress

NOTES: Science and mathematics scores are not comparable. Standard errors are shown in parentheses.

[1] Data for the NAEP science test are for 1977; data for the NAEP mathematics test are for 1978.

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics 1991).

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Appendix table 1–10.

Distribution of student proficiency scores by score range on the NAEP mathematics test, by sex and race/ethnicity for age 13: 1978–90

Sex, race/ethnicity, and score range	1978	1982	1986	1990
	Percent			
All students				
Less than 200	5.4	2.3	1.4	1.5
200–249	29.7	26.3	25.3	23.8
250–299	46.9	54.0	57.5	57.4
300–349	17.0	16.9	15.4	16.9
350 or more	1.0	0.5	0.4	0.4
Male				
Less than 200	6.1	2.5	1.5	1.8
200–249	30.0	26.2	24.7	23.1
250–299	45.5	52.4	56.2	56.1
300–349	17.3	18.2	17.1	18.5
350 or more	1.1	0.7	0.5	0.5
Female				
Less than 200	4.8	2.0	1.4	1.1
200–249	29.3	26.6	25.9	24.5
250–299	48.4	55.5	58.6	58.7
300–349	16.6	15.5	13.8	15.5
350 or more	0.9	0.4	0.3	0.2
White				
Less than 200	2.4	0.9	0.7	0.6
200–249	24.7	20.8	20.4	17.4
250–299	51.5	57.8	60.3	61.0
300–349	20.2	19.9	18.2	20.6
350 or more	1.2	0.6	0.4	0.4
Black				
Less than 200	20.3	9.8	4.6	4.6
200–249	51.0	52.3	46.4	46.7
250–299	26.4	35.0	45.0	44.8
300–349	2.3	2.9	3.9	3.8
350 or more	0	0	0.1	0.1
Hispanic				
Less than 200	13.6	4.1	3.1	3.2
200–249	50.4	43.7	40.9	40.1
250–299	32.0	45.9	50.5	50.3
300–349	3.9	6.3	5.3	6.3
350 or more	0.1	0	0.2	0.1

Less than 200—Simple arithmetic facts. Students at this level know some basic addition and subtraction facts, and most can add two-digit numbers without regrouping. They recognize simple situations in which addition and subtraction apply. They also are developing rudimentary classification skills.

200—Beginning skills and understandings. Students at this level have considerable understanding of two-digit numbers. They can add two-digit numbers, but are still developing an ability to regroup in subtraction. They know some basic multiplication and division facts, recognize relations among coins, can read information from charts and graphs, and use simple measurement instruments. They are developing some reasoning skills.

250—Basic operations and beginning problem-solving. Students at this level have an initial understanding of the four basic operations. They are able to apply whole number addition and subtraction skills to one-step word problems and money situations. In multiplication, they can find the product of a two-digit and a one-digit number. They can also compare information from graphs and charts and are developing an ability to analyze simple logical relations.

300—Moderately complex procedures and reasoning. Students at this level are developing an understanding of number systems. They can compute with decimals, simple fractions, and commonly encountered percents. They can identify geometric figures, measure lengths and angles, and calculate areas of rectangles. These students are also able to interpret simple inequalities, evaluate formulas, and solve simple linear equations. They can find averages, make decisions on information drawn from graphs, and use logical reasoning to solve problems. They are developing the skills to operate with signed numbers, exponents, and square roots.

350—Multi-step problem-solving and algebra. Students at this level can apply a range of reasoning skills to solve multi-step problems. They can solve routine problems involving fractions and percents, recognize properties of basic geometric figures, and work with exponents and square roots. They can solve a variety of two-step problems using variables, identify equivalent algebraic expressions, and solve linear equations and inequalities. They are developing an understanding of functions and coordinate systems.

NAEP = National Assessment of Educational Progress

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

Appendix table 1–11.

Distribution of student proficiency scores on the NAEP mathematics test, by sex and race/ethnicity for age 17: 1978–90

Sex, race/ethnicity, and score range	1978	1982	1986	1990
	Percent			
All students				
Less than 200	0.2	0.1	0.1	0
200–249	7.8	6.9	4.3	4.0
250–299	40.5	44.5	43.9	39.9
300–349	44.2	43.0	45.2	48.9
350 or more	7.3	5.5	6.5	7.2
Male				
Less than 200	0.1	0	0.1	0.1
200–249	6.9	6.1	3.8	4.1
250–299	37.9	42.0	41.5	38.2
300–349	45.6	45.0	46.2	48.8
350 or more	9.5	6.9	8.4	8.8
Female				
Less than 200	0.3	0.1	0	0
200–249	8.7	7.8	4.9	3.8
250–299	42.8	46.8	46.2	41.5
300–349	43.0	41.2	44.2	49.1
350 or more	5.2	4.1	4.7	5.6
White				
Less than 200	0	0	0	0
200–249	4.4	3.8	2.0	2.4
250–299	38.0	41.5	38.9	34.4
300–349	49.1	48.3	51.2	54.9
350 or more	8.5	6.4	7.9	8.3
Black				
Less than 200	1.2	0.3	0	0.1
200–249	28.1	23.3	14.4	7.6
250–299	53.9	59.3	64.8	59.6
300–349	16.3	16.6	20.6	30.8
350 or more	0.5	0.5	0.2	2.0
Hispanic				
Less than 200	0.7	0.2	0.6	0.4
200–249	21.0	18.4	10.1	13.8
250–299	54.9	59.8	62.8	55.7
300–349	22.0	20.9	25.4	28.2
350 or more	1.4	0.7	1.1	1.9

NAEP = National Assessment of Educational Progress

NOTE: See appendix table 1–10 for descriptions of proficiency levels.

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

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Appendix table 1–12.

Distribution of student proficiency scores by score range on the NAEP science test, by sex and race/ethnicity for age 13: 1977–90

Sex, race/ethnicity, and score range	1977	1982	1986	1990
	Percent			
All students				
Less than 200	14.0	10.2	8.4	7.7
200–249	37.2	38.9	39.1	35.8
250–299	37.7	41.3	43.4	45.3
300–349	10.4	9.2	8.9	10.8
350 or more	0.7	0.4	0.2	0.4
Male				
Less than 200	12.8	8.1	7.1	7.3
200–249	34.9	35.7	35.6	32.9
250–299	39.2	43.6	45.4	45.8
300–349	12.2	12.1	11.6	13.4
350 or more	0.9	0.5	0.3	0.6
Female				
Less than 200	15.3	12.1	9.7	8.0
200–249	36.3	41.9	42.6	38.7
250–299	36.4	39.1	41.4	44.8
300–349	8.6	6.7	6.2	8.3
350 or more	0.4	0.2	0.1	0.2
White				
Less than 200	7.8	5.6	3.9	3.1
200–249	35.7	36.1	35.1	30.4
250–299	43.1	46.8	49.7	52.3
300–349	12.6	11.1	11.0	13.7
350 or more	0.8	0.4	0.3	0.5
Black				
Less than 200	42.7	31.4	26.4	22.4
200–249	42.4	51.5	54.0	53.3
250–299	13.7	16.3	18.5	22.8
300–349	1.2	0.8	1.1	1.4
350 or more	0	0	0	0.1
Hispanic				
Less than 200	37.8	24.5	23.3	19.8
200–249	44.1	51.4	51.8	50.2
250–299	16.3	21.7	23.4	[illegible]
300–349	1.8	2.4	1.5	3.2
350 or more	0	0	0	0.1

NAEP = National Assessment of Educational Progress

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

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Less than 200—Knows everyday science facts. Students at this level know some general scientific facts of the type that could be learned from everyday experiences. They can read simple graphs, match the distinguishing characteristics of animals, and predict the operation of familiar apparatuses that work according to mechanical principles.

200—Understands simple scientific principles. Students at this level are developing some understanding of simple scientific principles, particularly in the life sciences. For example, they exhibit some rudimentary knowledge of the structure and function of plants and animals.

250—Applies basic scientific information. Students at this level can interpret data from simple tables and make inferences about the outcomes of experimental procedures. They exhibit knowledge and understanding of the life sciences, including a familiarity with some aspects of animal behavior and of ecological relationships. These students also demonstrate some knowledge of basic information from the physical sciences.

300—Analyzes scientific procedures and data. Students at this level can evaluate the appropriateness of the design of an experiment. They have more detailed scientific knowledge and the skill to apply their knowledge in interpreting information from text and graphs. These students also exhibit a growing understanding of principles from the physical sciences.

350—Integrates specialized scientific information. Students at this level can infer relationships and draw conclusions using detailed scientific knowledge from the physical sciences, particularly chemistry. They also can apply basic principles of genetics and interpret the societal implications of research in this field.

Appendix table 1–13.
Distribution of student proficiency scores by score range on the NAEP science test, by sex and race/ethnicity for age 17: 1977–90

Sex, race/ethnicity, and score range	1977	1982	1986	1990
	Percent			
All students				
Less than 200	2.9	4.3	2.9	3.3
200–249	15.5	19.1	16.4	15.5
250–299	39.9	39.3	39.4	37.8
300–349	33.2	30.2	33.4	34.2
350 or more	8.5	7.1	7.9	9.2
Male				
Less than 200	2.2	3.2	2.6	3.2
200–249	12.6	15.6	15.0	14.3
250–299	36.4	36.0	33.6	34.3
300–349	37.0	34.8	37.4	35.2
350 or more	11.8	10.4	11.4	13.0
Female				
Less than 200	3.6	5.4	3.1	3.4
200–249	18.4	22.4	17.8	16.7
250–299	43.2	42.3	45.0	41.2
300–349	29.5	26.0	29.6	33.2
350 or more	5.3	3.9	4.5	5.5
White				
Less than 200	0.8	1.4	1.2	1.0
200–249	11.0	13.7	11.0	9.4
250–299	40.7	41.0	39.1	38.4
300–349	37.5	35.3	39.1	39.8
350 or more	10.0	8.6	9.6	11.4
Black				
Less than 200	16.4	20.3	9.1	11.7
200–249	43.1	44.7	38.7	36.9
250–299	32.8	28.5	39.7	35.7
300–349	7.3	6.6	11.6	14.2
350 or more	0.4	0.2	0.9	1.5
Hispanic				
Less than 200	6.9	13.1	6.7	8.1
200–249	31.6	38.9	33.3	32.0
250–299	43.0	36.9	45.2	38.8
300–349	16.7	9.7	13.7	19.0
350 or more	1.8	1.4	1.1	2.1

NAEP = National Assessment of Educational Progress

NOTE: See appendix table 1–12 for descriptions of proficiency levels.

SOURCE: Educational Testing Service, *Trends in Academic Progress* (Washington, DC: National Center for Education Statistics, 1991).

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Appendix table 1–14.
NAEP mathematics test proficiency levels, by age: 1990 and 1992

Level and description	Grade	Assessment year			
		1990		1992	
		Percentage at or above level			
200—Addition and subtraction, and simple problem solving with whole numbers. Students at this level can identify solutions to one-step word problems involving addition or subtraction. They can add and subtract whole numbers in most situations, and, when a calculator is available, they can multiply and divide. They are able to select the largest whole number from a set of numbers in the thousands and can match numbers' verbal and symbolic names. They demonstrate familiarity with length and weight by selecting appropriate instruments and units to measure these attributes. They are able to recognize some basic properties of two-dimensional geometric figures as well as the names of standard examples of these figures. They can recognize simple patterns.	4	67	(1.4)	72*	(0.9)
	8	95	(0.7)	97	(0.4)
	12	100	(0.2)	100	(0.1)
250-Multiplication and division, simple measurement, and two-step problem solving. When presented with a problem situation, students at this level have some understanding of the problem, can identify extraneous information, and have some knowledge of when to use computational estimation. they have an understanding of addition, subtraction, multiplication, and division with whole numbers. They can solve simple two-step problems involving whole numbers. They are able to round whole numbers and solve simple word problems involving place value, estimation, and multiples. Students can use a ruler to measure length in centimeters and have some understanding of area and perimeter. They can solve problems that require visualizing, drawing, or manipulating simple geometric shapes. They are able to complete bar graphs and pictographs, as well as use information from graphs or tables to solve simple problems. They can recognize simple number patterns, are beginning to deal informally with the idea of a variable, and have some knowledge of simple probability.	4	12	(1.1)	17*	(0.8)
	8	65	(1.4)	68	(1.0)
	12	88	(0.9)	91*	(0.5)
300—Reasoning and problem solving involving fractions, decimals, percents, elementary concepts in geometry, statistics, and algebra. Students at this level can use various strategies and explain their reasoning in a variety of problem-solving situations. They are able to solve problems involving not only whole numbers but with decimals and fractions. They can represent and find equivalent fractions and use these concepts in solving routine problems. They can find a percent of a number and use this skill in simple problems. Multiplication and division of whole numbers have developed to the extent that students can use all four operations in multi-step problems. Students can read and use instruments in more complex situations. They can find areas of rectangles, recognize relationships among common units of measure, and solve routine problems involving similar triangles and scale drawings. They have knowledge of definitions and properties of simple geometric figures in the plane. Their spatial sense includes the ability to visualize a cube in either three-space or its flattened form in a plane. Students can calculate averages, select and interpret data from a variety of graphs, list the possible arrangements in a sample space, find the probability of a simple event, and have a beginning understanding of sample bias. They can use knowledge of relative frequencies in simple simulation situations. Students show the ability to evaluate simple expressions and solve linear equations. Students can graph points on coordinate axes, locate the missing coordinates for a corner of a square, and identify which ordered paris satisfy a given linear equation.	4	0	(0.1)	0	(0.1)
	8	15	(1.0)	20	(0.9)
	12	45	(1.4)	50*	(1.2)
350—Reasoning and problem solving involving geometric relationships, algebra, and functions. Students at this level can reason and estimate with percents. They can recognize scientific notation and find the decimal equivalent. They can apply their knowledge of area and perimeter of simple geometric figures to solve problems. They can find the circumferences of circles and the surface areas of solid figures. They can solve for the length of missing segments in more complex similarity situations. Students can apply the Pythagorean Theorem to find the hypotenuse of a right triangle. They are beginning to use rectangular coordinates in problem-solving situations and can apply geometric properties and relationships in solving problems. Students can compute means from frequency tables and create a sample space to determine probabilities, and read the graph of a step-function. Students can use exponents and evaluate expressions given in functional notation. In number theory, they have an understanding of even and odd numbers and their properties. They can identify an equation describing a linear relation provided in a table, and solve literal equations and systems of two linear equations. They have some knowledge of trigonometric relations. These students can represent and interpret complex patterns and data using numbers, expressions, and graphs. Given the graph of a function, they can identify its zeros and the effect on the graph of taking the absolute value of the function.	4	0	(0.0)	0	(0.0)
	8	0	(0.2)	1	(0.2)
	12	5	(0.8)	6	(0.5)

* = significantly higher than 1990 value at about the 95-percent confidence interval; NAEP = National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

SOURCE: National Center for Education Statistics, *NAEP 1992 Mathematics Report Card for the Nation and the States* (Washington, DC: 1993).

Appendix table 1–15.

NAEP mathematics test achievement levels for grade 4, by sex and race/ethnicity: 1990 and 1992

Sex and race/ethnicity		Average score	Proportion of total	Achievement level[1]			
				Advanced	Proficient	Basic	Below basic
			Percent				
All students	1990	213 (0.9)	100	1	12	41	46
	1992	218 (0.7)	100	2	16	43	39
Male	1990	214 (1.2)	52	2	12	41	45
	1992	220 (0.8)	50	3	17	42	38
Female	1990	212 (1.1)	48	1	12	40	47
	1992	217 (1.0)	50	2	15	42	41
White	1990	220 (1.1)	70	2	15	47	36
	1992	227 (0.9)	70	3	20	49	28
Asian	1990	228 (3.5)	2	4	20	45	31
	1992	231 (2.4)	2	5	25	46	24
Black	1990	189 (1.8)	15	0	2	20	78
	1992	192 (1.3)	16	0	3	21	76
Hispanic	1990	198 (2.0)	10	0	5	29	66
	1992	201 (1.4)	10	0	6	31	63
Native American	1990	208 (3.9)	2	0	5	43	52
	1992	209 (3.2)	2	2	8	36	54

For fourth graders, the five NAEP content areas are (1) numbers and operations; (2) measurement; (3) geometry; (4) data analysis, statistics, and probability; and (5) algebra and functions. At the fourth grade level, algebra functions are treated in informal and exploratory ways, often through the study of patterns. Skills are cumulative across levels—from basic to proficient to advanced.

- **Basic (211).** Fourth graders performing at the basic level should be able to estimate and use basic facts to perform simple computations with whole numbers, show some understanding of fractions and decimals, and solve some simple real-world problems in all NAEP content areas. Students at this level should be able to use—though not always accurately—four-function calculators, rulers, and geometric shapes. Their written responses are often minimal and presented without supporting information.
- **Proficient (248).** Fourth graders performing at the proficient level should be able to use whole numbers to estimate, compute, and determine whether results are reasonable. They should have a conceptual understanding of fractions and decimals; be able to solve real-world problems in all NAEP content areas; and use four-function calculators, rulers, and geometric shapes appropriately. They should employ problem-solving strategies such as identifying and using appropriate information. Their written solutions should be organized and presented both with supporting information and explanations of how they were achieved.
- **Advanced (280).** Fourth graders performing at the advanced level should be able to solve complex and nonroutine real-world problems in all NAEP content areas. They should display mastery in the use of four-function calculators, rulers, and geometric shapes. These students are expected to draw logical conclusions and justify answers and solution process by explaining why, as well as how, they were achieved. They should go beyond the obvious in their interpretations and be able to communicate their thoughts clearly and concisely.

NAEP = National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

[1] Data are for the percentage who reached but did not surpass the given level.

SOURCE: National Center for Education Statistics, *NAEP 1992 Mathematics Report Card for the Nation and the States* (Washington, DC: 1993).

See figure 1–4 and text table 1-1.

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Appendix table 1–16.

NAEP mathematics test achievement levels for grade 8, by sex and race/ethnicity: 1990 and 1992

Race/ethnicity		Average score	Proportion of total	Achievement level[1]			
				Advanced	Proficient	Basic	Below basic
			Percent				
All students	1990	263 (1.3)	100	2	18	38	42
	1992	268 (0.9)	100	4	21	38	37
Male	1990	263 (1.6)	51	3	18	37	42
	1992	267 (1.1)	51	4	21	37	38
Female	1990	262 (1.3)	49	2	16	41	41
	1992	268 (1.0)	49	4	20	39	37
White	1990	270 (1.4)	71	3	21	44	32
	1992	277 (1.0)	70	4	28	42	26
Asian	1990	279 (4.8)	2	6	32	38	24
	1992	288 (5.5)	2	14	30	36	20
Black	1990	238 (2.7)	15	0	6	22	72
	1992	237 (1.4)	16	0	3	24	73
Hispanic	1990	244 (2.8)	10	0	6	32	62
	1992	246 (1.2)	10	1	7	31	61
Native American	1990	246 (9.4)	2	0	9	30	61
	1992	254 (2.8)	1	0	9	38	53

For eighth graders, the five NAEP content areas are (1) numbers and operations; (2) measurement; (3) geometry; (4) data analysis, statistics, and probability; and (5) algebra and functions. Skills are cumulative across levels—from basic to proficient to advanced.

- **Basic (256).** Eighth graders performing at the basic level should complete problems correctly with the help of structural prompts such as diagrams, charts, and graphs. They should be able to solve problems in all NAEP content areas through the appropriate selection and use of strategies and technological tools—including calculators, computers, and geometric shapes. Students at this level also should be able to use fundamental algebraic and informal geometric concepts in problem solving. As they approach the proficient level, students at the basic level should be able to determine which of available data are necessary and sufficient for correct solutions and use them in problem solving. However, these eighth graders show limited skill in communicating mathematically.
- **Proficient (294).** Eighth graders performing at the proficient level should be able to conjecture, defend their ideas, and give supporting examples. They should understand the connections between fractions, percents, decimals, and other mathematical topics such as algebra and functions. Students at this level are expected to have a thorough understanding of basic level arithmetic operations—an understanding sufficient for problem solving in practical situations. Quantity and spatial relationships in problem solving and reasoning should be familiar to them, and they should be able to convey underlying reasoning skills beyond the level of arithmetic. They should be able to compare and contrast mathematical ideas and generate their own examples. These students should make inferences from data and graphs, apply properties of informal geometry, and accurately use the tools of technology. They should understand the process of gathering and organizing data and be able to calculate, evaluate, and communicate results within the domain of statistics and probability.
- **Advanced (331).** Eighth graders performing at the advanced level should be able to probe examples and counter examples in order to shape generalizations from which they can develop models. They should use number sense and geometric awareness to consider the reasonableness of an answer. They are expected to use abstract thinking to create unique problem-solving techniques and explain the reasoning processes underlying their conclusions.

NAEP = National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

[1] Data are for the percentage who reached but did not surpass the given level.

SOURCE: National Center for Education Statistics, *NAEP 1992 Mathematics Report Card for the Nation and the States* (Washington, DC: 1993).

See figure 1–4 and text table 1-1.

Appendix table 1–17.

NAEP mathematics test achievement levels for grade 12, by race/ethnicity: 1990 and 1992

Race/ethnicity		Average score	Proportion of total	Achievement level[1]			
				Advanced	Proficient	Basic	Below basic
				Percent			
All students	1990	294 (1.1)	100	2	11	46	41
	1992	299 (0.9)	100	2	14	48	36
Male	1990	297 (1.4)	48	3	13	45	39
	1992	301 (1.1)	49	3	15	47	35
Female	1990	292 (1.3)	52	1	9	47	43
	1992	297 (1.0)	51	1	13	49	37
White	1990	300 (1.2)	74	2	14	51	33
	1992	305 (0.9)	71	2	17	53	28
Asian	1990	311 (5.2)	3	5	20	51	24
	1992	315 (3.5)	4	6	25	50	19
Black	1990	268 (1.9)	14	0	2	26	72
	1992	275 (1.7)	15	0	3	31	66
Hispanic	1990	276 (2.8)	8	0	4	33	63
	1992	283 (1.8)	10	1	5	39	55
Native American	1990	288 (10.2)	1	0	4	58	38
	1992	281 (9.0)	1	0	4	42	54

For 12th graders, the five NAEP content areas are (1) numbers and operations; (2) measurement; (3) geometry; (4) data analysis, statistics, and probability; and (5) algebra and functions. Skills are cumulative across levels—from basic to proficient to advanced.

- **Basic (287).** Twelfth grade students performing at the basic level should be able to use estimation to verify solutions and determine the reasonableness of results as applied to real-world problems. They are expected to use algebraic and geometric reasoning strategies to solve problems. They should recognize relationships presented in verbal, algebraic, tabular, and graphical forms; and demonstrate knowledge of geometric relationships and corresponding measurement skills. They should be able to apply statistical reasoning in the organization and display of data and in reading tables and graphs. They also should be able to generalize from patterns and examples in the areas of algebra, geometry, and statistics. At this level, they should use correct mathematical language and symbols to communicate mathematical relationships and reasoning processes, and use calculators appropriately to solve problems.
- **Proficient (334).** Twelfth graders performing at the proficient level should demonstrate an understanding of algebraic, statistical, and geometric and spatial reasoning. They should be able to perform algebraic operations involving polynomials, justify geometric relationships, and judge and defend the reasonableness of answers as applied to real-world situations. These students should be able to analyze and interpret data in tabular and graphical form; understand and use elements of the function concept in symbolic, graphical, and tabular form; and make conjectures, defend ideas, and give supporting examples.
- **Advanced (366).** Twelfth grade students performing at the advanced level should understand the function concept; and be able to compare and apply the numeric, algebraic, and graphical properties of functions. They should apply their knowledge of algebra, geometry, and statistics to solve problems in more advanced areas of continuous and discrete mathematics. They should be able to formulate generalizations and create models through probing examples and counter examples. They should be able to communicate their mathematical reasoning through the clear, concise, and correct use of mathematical symbolism and logical thinking.

NAEP = National Assessment of Educational Progress

NOTE: Standard errors are shown in parentheses.

[1] Data are for the percentage who reached but did not surpass the given level.

SOURCE: National Center for Education Statistics, *NAEP 1992 Mathematics Report Card for the Nation and the States* (Washington, DC: 1993).

See figure 1–4 and text table 1-1.

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Appendix table 1–18.

Distribution of scores on the mathematics SAT, by sex—all students: 1987 and 1992

Score range	All students	Males	Females	All students	Males	Females
	Number			Percent		
			1987			
Total test–takers	1,080,426	520,326	560,100			
200–249	11,823	4,377	7,446	1.1	0.8	1.3
250–299	60,562	22,100	38,462	5.6	4.2	6.9
300–349	98,146	37,270	60,876	9.1	7.2	10.9
350–399	136,231	54,035	82,196	12.6	10.4	14.7
400–449	153,459	64,848	88,611	14.2	12.5	15.8
450–499	162,476	73,681	88,795	15.0	14.2	15.9
500–549	137,116	68,048	69,068	12.7	13.1	12.3
550–599	122,642	66,808	55,834	11.4	12.8	10.0
600–649	90,548	53,871	36,677	8.4	10.4	6.5
650–699	65,698	43,266	22,432	6.1	8.3	4.0
700–749	30,737	22,897	7,840	2.8	4.4	1.4
750–800	10,988	9,125	1,863	1.0	1.8	0.3
			1992			
Total test–takers	1,034,131	491,748	542,383			
200–249	13,414	4,982	8,432	1.3	1.0	1.6
250–299	52,302	19,362	32,940	5.1	3.9	6.1
300–349	97,115	37,135	59,980	9.4	7.6	11.1
350–399	128,711	51,452	77,259	12.4	10.5	14.2
400–449	143,226	60,496	82,730	13.8	12.3	15.3
450–499	150,941	68,108	82,833	14.6	13.9	15.3
500–549	150,284	73,137	77,147	14.5	14.9	14.2
550–599	110,741	58,805	51,936	10.7	12.0	9.6
600–649	82,996	48,034	34,962	8.0	9.8	6.4
650–699	56,882	36,001	20,881	5.5	7.3	3.8
700–749	33,387	23,209	10,178	3.2	4.7	1.9
750–800	14,132	11,027	3,105	1.4	2.2	0.6

SAT = Scholastic Aptitude Test

SOURCES: The College Board, *College–Bound Seniors: 1987 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1987); and The College Board, *College–Bound Seniors: 1992 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1992).

See figures 1–7 and 1–8.

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Appendix table 1–19.

Distribution of scores on the mathematics SAT, by sex—white students: 1987 and 1992

Score range	All students	Males	Females	All students	Males	Females
	Number			Percent		
			1987			
Total test-takers	788,613	378,278	410,335			
200–249	4,346	1,501	2,845	0.6	0.4	0.7
250–299	28,893	9,947	18,946	3.7	2.6	4.6
300–349	57,838	21,015	36,823	7.3	5.6	9.0
350–399	91,828	35,175	56,653	11.6	9.3	13.8
400–449	113,172	46,106	67,066	14.4	12.2	16.3
450–499	125,741	55,316	70,425	15.9	14.6	17.2
500–549	109,576	53,251	56,325	13.9	14.1	13.7
550–599	99,391	53,244	46,147	12.6	14.1	11.2
600–649	73,253	43,287	29,966	9.3	11.4	7.3
650–699	52,908	34,853	18,055	6.7	9.2	4.4
700–749	23,679	17,839	5,840	3.0	4.7	1.4
750–800	7,988	6,744	1,244	1.0	1.8	0.3
			1992			
Total test-takers	680,806	321,665	359,141			
200–249	4,181	1,403	2,778	0.6	0.4	0.8
250–299	20,993	7,188	13,805	3.1	2.2	3.8
300–349	49,044	17,681	31,363	7.2	5.5	8.7
350–399	77,003	29,208	47,795	11.3	9.1	13.3
400–449	95,104	38,521	56,583	14.0	12.0	15.8
450–499	107,209	46,931	60,278	15.7	14.6	16.8
500–549	111,367	53,118	58,249	16.4	16.5	16.2
550–599	83,059	43,600	39,459	12.2	13.6	11.0
600–649	61,710	35,642	26,068	9.1	11.1	7.3
650–699	40,740	25,985	14,755	6.0	8.1	4.1
700–749	22,153	15,746	6,407	3.3	4.9	1.8
750–800	8,243	6,642	1,601	1.2	2.1	0.4

SAT = Scholastic Aptitude Test

SOURCES: The College Board, *College–Bound Seniors: 1987 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1987); and The College Board, *College–Bound Seniors: 1992 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1992).

See figures 1–8 and 1–9.

Science & Engineering Indicators – 1993

Appendix table 1-20.
Distribution of scores on the mathematics SAT, by sex—Asian students: 1987 and 1992

Score range	All students	Males	Females	All students	Males	Females
	Number			Percent		
			1987			
Total test-takers	58,216	30,220	27,996			
200–249	434	178	256	0.7	0.6	0.9
250–299	2,005	830	1,175	3.4	2.7	4.2
300–349	3,512	1,435	2,077	6.0	4.7	7.4
350–399	5,318	2,206	3,112	9.1	7.3	11.1
400–449	6,472	2,948	3,524	11.1	9.8	12.6
450–499	7,503	3,554	3,949	12.9	11.8	14.1
500–549	7,076	3,535	3,541	12.2	11.7	12.6
550–599	7,270	3,846	3,424	12.5	12.7	12.2
600–649	6,820	3,802	3,018	11.7	12.6	10.8
650–699	5,885	3,649	2,236	10.1	12.1	8.0
700–749	3,976	2,730	1,246	6.8	9.0	4.5
750–800	1,945	1,507	438	3.3	5.0	1.6
			1992			
Total test-takers	78,387	39,182	39,205			
200–249	609	213	396	0.7	0.6	0.8
250–299	2,280	866	1,414	2.6	2.4	2.7
300–349	4,383	1,705	2,678	5.6	4.4	6.8
350–399	6,453	2,641	3,812	8.2	6.7	9.7
400–449	8,017	3,455	4,562	10.2	8.8	11.6
450–499	9,330	4,198	5,132	11.9	10.7	13.1
500–549	10,569	5,030	5,539	13.5	12.8	14.1
550–599	9,539	4,788	4,751	12.2	12.2	12.1
600–649	8,951	4,827	4,124	11.4	12.3	10.5
650–699	7,816	4,511	3,305	10.0	11.5	8.4
700–749	6,443	4,065	2,378	8.2	10.4	6.1
750–800	3,997	2,883	1,114	5.1	7.4	2.8

SAT = Scholastic Aptitude Test

SOURCES: The College Board, *College–Bound Seniors: 1987 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1987); and The College Board, *College–Bound Seniors: 1992 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1992).

See figures 1-8 and 1-9.

Science & Engineering Indicators – 1993

Appendix table 1–21.
Distribution of scores on the mathematics SAT, by sex—black students: 1987 and 1992

Score range	All students	Males	Females	All students	Males	Females
	Number			Percent		
			1987			
Total test–takers	88,037	36,193	51,844			
200–249	3,928	1,471	2,457	4.5	4.1	4.7
250–299	15,992	5,796	10,196	18.2	16.0	19.7
300–349	18,060	6,766	11,294	20.5	18.7	21.8
350–399	17,242	6,705	10,537	19.6	18.5	20.3
400–449	12,626	5,293	7,333	14.3	14.6	14.1
450–499	9,098	4,089	5,009	10.3	11.3	9.7
500–549	5,121	2,520	2,601	5.8	7.0	5.0
550–599	3,190	1,788	1,402	3.6	4.9	2.7
600–649	1,684	1,002	682	1.9	2.8	1.3
650–699	795	525	270	0.9	1.5	0.5
700–749	252	195	57	0.3	0.5	0.1
750–800	49	43	6	0.1	0.1	0.0
			1992			
Total test–takers	99,126	41,649	57,477	4.3	3.8	4.6
200–249	4,257	1,595	2,662	14.6	13.2	15.6
250–299	14,444	5,497	8,947	20.7	19.1	22.0
300–349	20,564	7,946	12,618	19.4	18.7	20.0
350–399	19,273	7,790	11,483	15.3	15.4	15.2
400–449	15,181	6,418	8,763	11.0	11.7	10.5
450–499	10,867	4,860	6,007	7.4	8.4	6.7
500–549	7,379	3,516	3,863	3.8	4.7	3.1
550–599	3,757	1,957	1,800	2.0	2.8	1.5
600–649	2,018	1,161	857	1.0	1.5	0.6
650–699	956	610	346	0.3	0.6	0.2
700–749	340	231	109	0.1	0.2	0.0
750–800	90	68	22			

SAT = Scholastic Aptitude Test

SOURCES: The College Board, *College–Bound Seniors: 1987 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1987); and The College Board, *College–Bound Seniors: 1992 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1992).

See figures 1–8 and 1–9.

Science & Engineering Indicators – 1993

Appendix table 1–22.

Distribution of scores on the mathematics SAT, by sex—Hispanic students: 1987 and 1992

(page 1 of 2)

Score range	All students	Males	Females	All students	Males	Females
	Number			Percent		
			Latin Americans			
Total test–takers, 1987	18,895	10,157	9,997			
200–249	422	1,398	283	2.2	13.8	2.8
250–299	1,903	648	1,255	10.1	6.4	12.6
300–349	2,554	919	1,635	13.5	9.0	16.4
350–399	3,014	1,217	1,797	16.0	12.0	18.0
400–449	2,953	1,318	1,635	15.6	13.0	16.4
450–499	2,649	1,341	1,308	14.0	13.2	13.1
500–549	1,980	1,095	885	10.5	10.8	8.9
550–599	1,507	894	613	8.0	8.8	6.1
600–649	965	644	321	5.1	6.3	3.2
650–699	623	442	181	3.3	4.4	1.8
700–749	257	187	70	1.4	1.8	0.7
750–800	68	54	14	0.4	0.5	0.1
Total test–takers, 1992	26,766	12,040	14,726			
200–249	684	221	463	2.6	1.8	3.1
250–299	2,311	722	1,589	8.6	6.0	10.8
300–349	3,845	1,381	2,464	14.4	11.5	16.7
350–399	4,401	1,715	2,686	16.4	14.2	18.2
400–449	3,987	1,718	2,269	14.9	14.3	15.4
450–499	3,697	1,735	1,962	13.8	14.4	13.3
500–549	3,103	1,597	1,506	11.6	13.3	10.2
550–599	2,050	1,162	888	7.7	9.7	6.0
600–649	1,361	858	503	5.1	7.1	3.4
650–699	799	529	270	3.0	4.4	1.8
700–749	403	300	103	1.5	2.5	0.7
750–800	125	102	23	0.5	0.8	0.2
			Mexican–Americans			
Total test–takers, 1987	20,714	9,605	11,109			
200–249	361	123	238	1.7	1.3	2.1
250–299	1,916	639	1,277	9.2	6.7	11.5
300–349	3,103	1,145	1,958	15.0	11.9	17.6
350–399	3,783	1,483	2,300	18.3	15.4	20.7
400–449	3,455	1,544	1,911	16.7	16.1	17.2
450–499	3,054	1,530	1,524	14.7	15.9	13.7
500–549	1,967	1,079	888	9.5	11.2	8.0
550–599	1,564	953	611	7.6	9.9	5.5
600–649	890	618	272	4.3	6.4	2.4
650–699	427	328	99	2.1	3.4	0.9
700–749	145	118	27	0.7	1.2	0.2
750–800	49	45	4	0.2	0.5	0.0
Total test–takers, 1992	30,336	13,751	16,585			
200–249	606	207	399	2.0	1.5	2.4
250–299	2,523	815	1,708	8.3	5.9	10.3
300–349	4,460	1,666	2,794	14.7	12.1	16.8
350–399	5,385	2,157	3,228	17.8	15.7	19.5
400–449	5,283	2,246	3,037	17.4	16.3	18.3
450–499	4,335	2,093	2,242	14.3	15.2	13.5
500–549	3,513	1,845	1,668	11.6	13.4	10.1
550–599	2,063	1,212	851	6.8	8.8	5.1
600–649	1,187	761	426	3.9	5.5	2.6
650–690	636	466	170	2.1	3.4	1.0
700–749	271	215	56	0.9	1.6	0.3
750–800	74	68	6	0.2	0.5	0.0

(continued)

Appendix table 1–22.

Distribution of scores on the mathematics SAT, by sex—Hispanic students: 1987 and 1992

(page 2 of 2)

Score range	All students	Males	Females	All students	Males	Females
	Number			Percent		
			Puerto Ricans			
Total test–takers, 1987	10,304	4,636	5,668			
200–249	412	131	281	4.0	2.8	5.0
250–299	1,428	475	953	13.9	10.2	16.8
300–349	1,825	706	1,119	17.7	15.2	19.7
350–399	1,849	774	1,075	17.9	16.7	19.0
400–449	1,530	683	847	14.8	14.7	14.9
450–499	1,335	676	659	13.0	14.6	11.6
500–549	782	445	337	7.6	9.6	5.9
550–599	575	357	218	5.6	7.7	3.8
600–649	312	203	109	3.0	4.4	1.9
650–699	188	131	57	1.8	2.8	1.0
700–749	51	40	11	0.5	0.9	0.2
750–800	17	15	2	0.2	0.3	0.0
Total test–takers, 1992	12,091	5,304	6,795			
200–249	458	163	295	3.8	3.1	4.3
250–299	1,468	471	997	12.1	8.9	14.7
300–349	2,084	763	1,321	17.2	14.4	19.4
350–399	2,144	879	1,265	17.7	16.6	18.6
400–449	1,816	790	1,026	15.0	14.9	15.1
450–499	1,587	739	848	13.1	13.9	12.5
500–549	1,170	623	547	9.7	11.7	8.1
550–599	637	362	275	5.3	6.8	4.0
600–649	401	261	140	3.3	4.9	2.1
650–699	213	158	55	1.8	3.0	0.8
700–749	86	64	22	0.7	1.2	0.3
750–800	27	31	4	0.2	0.6	0.1

SAT = Scholastic Aptitude Test

SOURCES: The College Board, *College–Bound Seniors: 1987 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1987); and The College Board, *College–Bound Seniors: 1992 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1992).

See figures 1–8 and 1–9.

Science & Engineering Indicators – 1993

Appendix table 1–23.

Distribution of scores on the mathematics SAT, by sex—Native American students: 1987 and 1992

Score range	All students	Males	Females	All students	Males	Females
	Number			Percent		
			1987			
Total test-takers	10,107	4,863	5,244			
200–249	160	63	97	1.6	1.3	1.8
250–299	881	312	569	8.7	6.4	10.9
300–349	1,345	532	813	13.3	10.9	15.5
350–399	1,688	720	968	16.7	14.8	18.5
400–449	1,690	794	896	16.7	16.3	17.1
450–499	1,559	760	799	15.4	15.6	15.2
500–549	1,146	615	531	11.3	12.6	10.1
550–599	805	497	308	8.0	10.2	5.9
600–649	471	310	161	4.7	6.4	3.1
650–699	241	164	77	2.4	3.4	1.5
700–749	98	76	22	1.0	1.6	0.4
750–800	23	20	3	0.2	0.4	0.1
			1992			
Total test-takers	7,412	3,525	3,887			
200–249	140	65	75	1.9	1.8	1.9
250–299	532	193	339	7.2	5.5	8.7
300–349	941	352	589	12.7	10.0	15.2
350–399	1,110	454	656	15.0	12.9	16.9
400–449	1,230	560	670	16.6	15.9	17.2a
450–499	1,110	542	568	15.0	15.4	14.6
500–549	1,001	523	478	13.5	14.8	12.3
550–599	593	344	249	8.0	9.8	6.4
600–649	390	244	146	5.3	6.9	3.8
650–699	243	159	84	3.3	4.5	2.2
700–749	94	68	26	1.3	1.9	0.7
750–800	28	21	7	0.4	0.6	0.2

SAT = Scholastic Aptitude Test

SOURCES: The College Board, *College–Bound Seniors: 1987 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1987); and The College Board, *College–Bound Seniors: 1992 Profile of SAT and Achievement Test Takers* (Princeton: Educational Testing Service, 1992).

See figures 1–8 and 1–9.

Science & Engineering Indicators – 1993

Appendix table 1–24.

Minority student population and new minority and female high school teachers, by state: 1991

State	Minority students	New mathematics teachers		New science teachers	
		Minority	Female	Minority	Female
	Percent				
Alabama	37	41	61	4	65
Arizona	39	NA	NA	NA	NA
Arkansas	26	27	50	0	35
California	54	53	45	18	48
Colorado	25	25	47	2	67
Connecticut	25	23	67	9	73
Delaware	32	30	60	20	33
Florida	38	41	63	20	56
Hawaii	87	76	56	50	33
Idaho	0	8	41	0	50
Illinois	34	35	57	4	55
Indiana	14	14	50	2	64
Iowa	6	8	47	3	43
Kansas	15	14	44	2	43
Kentucky	10	10	66	5	61
Maine	0	3	42	NA	57
Maryland	38	NA	NA	NA	NA
Michigan	22	22	55	2	42
Minnesota	10	10	59	NA	47
Mississippi	52	48	69	16	56
Missouri	0	18	62	4	52
Montana	11	12	36	0	15
Nevada	26	26	42	9	41
New Jersey	35	32	70	11	47
New Mexico	58	58	47	28	31
New York	34	34	46	NA	61
North Carolina	34	32	72	12	67
North Dakota	9	NA	NA	NA	NA
Ohio	17	16	38	0	40
Oklahoma	26	28	60	0	50
Pennsylvania	28	17	51	11	40
Rhode Island	16	17	38	20	80
South Carolina	42	43	64	2	63
South Dakota	0	13	33	0	23
Texas	50	48	55	21	51
Utah	7	8	50	13	13
Vermont	2	3	33	0	67
Virginia	32	NA	NA	NA	NA
Wisconsin	15	NA	NA	NA	NA
Wyoming	10	10	27	0	45
Puerto Rico	100	100	56	100	77

NA = not available

NOTE: Data are as of October 1991, and reflect reports from 35 States and Puerto Rico.

SOURCES: R. Blank and D. Grubel, *State Indicators of Science and Mathematics Education 1993* (Washington, DC: Council of Chief State School Officers, 1993); and National Center for Education Statistics, *Schools and Staffing in the United States: A Statistical Profile, 1990–91* (Washington, DC: Department of Education, 1993).

Science & Engineering Indicators – 1993

Appendix table 1–25.

Mathematics and science teachers of grades 9–12 with majors in their field, by state: 1988 and 1991

State	Mathematics teachers with math majors		Science teachers with science majors	
	1988	1991	1988	1991
	Percent			
All states	63	61	64	70
Alabama	69	87	63	63
Alaska	32	25	55	68
Arizona	NA	64	51	69
Arkansas	63	67	54	48
California	37	33	54	62
Colorado	55	49	75	75
Connecticut	57	73	67	85
Delaware	NA	NA	NA	NA
District of Columbia	NA	NA	NA	NA
Florida	60	52	67	67
Georgia	76	75	62	77
Hawaii	NA	NA	NA	NA
Idaho	60	45	52	63
Illinois	67	63	63	77
Indiana	59	68	65	79
Iowa	64	57	68	72
Kansas	74	78	44	66
Kentucky	73	77	67	72
Louisiana	55	55	44	50
Maine	49	62	57	73
Maryland	90	68	NA	82
Massachusetts	61	58	62	84
Michigan	71	60	68	70
Minnesota	75	79	82	80
Mississippi	77	80	72	71
Missouri	71	70	76	65
Montana	62	72	68	71
Nebraska	67	76	55	72
Nevada	NA	67	NA	NA
New Hampshire	NA	NA	NA	NA
New Jersey	73	75	82	73
New Mexico	57	54	54	41
New York	67	60	69	84
North Carolina	60	73	64	84
North Dakota	65	69	74	63
Ohio	68	71	71	66
Oklahoma	52	65	56	58
Oregon	42	48	66	78
Pennsylvania	83	82	81	78
Rhode Island	NA	NA	NA	NA
South Carolina	68	71	78	64
South Dakota	65	67	44	57
Tennessee	57	51	44	52
Texas	60	54	57	56
Utah	40	47	37	66
Vermont	NA	NA	NA	NA
Virginia	71	62	77	69
Washington	43	43	43	64
West Virginia	74	74	58	70
Wisconsin	76	75	77	74
Wyoming	55	73	49	77

NA = not available

SOURCE: R. Blank and D. Gruebel, *State Indicators of Science and Mathematics Education* 1993 (Washington, DC: 1993); and R. Blank and M. Dalkilic, *State Indicators of Science and Mathematics Education* 1990 (Washington, DC: Council of Chief State School Officers, 1990).

Appendix table 1–26.

Teachers whose main or secondary assignment is mathematics or science, by age, sex, and race/ethnicity: 1987–88

Teacher level and field	Age						N	Sex				N	Race/ethnicity						N
	20–29		30–49		50 & over			Male		Female			Black		White		Other		
	Percent							Percent					Percent						
Elementary school	13.7	(2.0)	65.7	(2.1)	20.6	(1.7)	726	23.8	(1.8)	76.2	(1.8)	730	9.4	(1.3)	85.2	(1.5)	5.3	(1.1)	714
Math specialist	13.3	(2.7)	64.9	(2.4)	21.8	(2.4)	464	18.2	(1.9)	81.8	(1.9)	466	10.8	(1.8)	83.0	(2.0)	6.2	(1.6)	457
Science specialist	14.3	(2.2)	67.3	(3.5)	18.4	(2.5)	262	34.2	(3.7)	65.8	(3.7)	264	6.9	(1.8)	89.5	(2.1)	3.6	(1.4)	257
Secondary school	16.1	(0.4)	67.3	(0.4)	16.6	(0.4)	6,715	54.1	(0.8)	45.9	(0.8)	6,771	6.2	(0.4)	89.8	(0.4)	3.6	(0.3)	6,617
Math	16.3	(0.6)	67.7	(0.8)	16.1	(0.6)	3,659	49.8	(1.1)	50.2	(1.1)	3,690	6.8	(0.6)	88.8	(0.7)	4.1	(0.4)	3,613
Biology	14.7	(1.4)	68.9	(1.9)	16.3	(1.3)	1,052	57.8	(1.7)	42.2	(1.7)	1,060	3.8	(0.7)	92.3	(1.0)	3.9	(0.7)	1,035
Chemistry/physics	12.5	(1.3)	64.9	(2.4)	22.6	(2.2)	577	68.3	(1.9)	31.7	(1.9)	582	2.7	(0.7)	93.1	(1.1)	4.2	(0.9)	564
Earth science	20.7	(2.3)	68.1	(2.2)	11.6	(2.1)	395	60.1	(2.9)	39.9	(2.9)	397	9.0	(2.0)	87.2	(2.1)	3.8	(1.1)	389
General/other science	16.9	(1.4)	65.5	(1.8)	17.7	(1.3)	1,032	54.8	(1.7)	45.2	(1.7)	1,042	6.9	(1.0)	89.9	(1.2)	3.2	(0.6)	1,016

NOTES: Standard errors are shown in parentheses. Sample sizes are unweighted.

SOURCES: National Center for Education Statistics, *Schools and Staffing in the United States: A Statistical Profile, 1990–91* (Washington, DC: Department of Education, 1993).

See figure 1–11.

Science & Engineering Indicators – 1993

Appendix table 1–27.

Secondary school teachers whose main or secondary assignment is mathematics or science, by bachelors degree field: 1987–88

Teaching field	Bachelors degree field												
	Mathematics	Science	Biology	Chemistry	Earth science	Physics	Other physical sciences	Elementary education	Secondary education	Math education	Science education	Other	N
	Percent												
Elementary school													
All fields	0.3	1.0	NA	NA	NA	NA	NA	70.0	0.8	0.1	0.3	27.5	15,434
Mathematics specialist	2.6	2.0	NA	NA	NA	NA	NA	62.6	1.8	1.5	0.5	28.9	453
Science specialist	NA	10.5	NA	NA	NA	NA	NA	55.6	0.8	NA	2.5	29.4	255
Secondary school													
All fields	18.3	NA	17.1	4.5	1.7	1.4	2.1	10.4	3.8	9.1	3.9	27.8	6,610
Math	36.3	NA	1.9	1.4	0.4	1.1	1.7	12.3	3.6	17.8	0.7	22.8	3,169
Biology	0.0	NA	60.4	1.1	0.5	0.0	1.5	3.8	2.9	0.4	7.6	21.9	966
Chemistry/physics	2.6	NA	23.1	31.4	0.8	7.4	5.3	0.5	5.1	0.8	9.0	13.9	535
Earth science	0.7	NA	21.3	2.3	16.5	1.4	1.7	14.8	5.5	NA	5.8	29.8	339
General/other science	0.8	NA	28.7	7.1	2.9	1.2	3.3	11.7	4.4	0.6	9.2	30.1	872

NA = not available

NOTES: Standard errors are shown in parentheses.

SOURCE: National Center for Education Statisics, *Schools and Staffing Survey in the United States: A Statistical Profile, 1990-91* (Washington, DC: Department of Education, 1993).

Science & Engineering Indicators – 1993

Appendix table 2–1.

Participation rate of 22-year-olds in first university degree in the natural sciences and engineering, by region/country: Most current year

Region/Country	All first univ. degrees	Degree fields: Natural sciences	Degree fields: Social sciences	Degree fields: Engineering[1]	22-year-olds: Total number	22-year-olds: With first univ. degrees	22-year-olds: With NS&E degrees[2]
						Percent	Percent
Asia							
Total	1,673,901	252,767	95,071	261,410	44,043,600	3.8	1.2
China	308,930	49,834	25,305	112,814	25,428,000	1.2	0.6
India	750,000	146,774	NA	29,000	15,545,800	4.8	1.1
Japan[3]	400,103	25,153	56,264	81,355	1,787,400	22.4	6.0
Singapore	6,000	1,278	117	1,220	52,400	11.5	4.8
South Korea	165,916	23,195	10,211	28,071	859,000	19.3	6.0
Taiwan	42,952	6,533	3,174	8,950	371,000	11.6	4.2
Europe							
Total Europe	813,752	124,192	101,671	135,090	7,423,880	11.1	3.5
European Community	604,551	99,306	89,987	95,594	5,548,880	11.1	3.5
Belgium	17,666	2,012	4,060	1,911	148,260	11.9	2.7
Denmark	13,934	573	674	2,764	78,900	17.7	4.2
France	77,904	14,320	6,991	16,080	849,480	9.2	3.6
Germany	137,376	26,321	33,935	38,288	1,361,120	10.9	5.1
Greece	28,264	4,187	2,965	2,447	154,560	18.3	4.3
Ireland	8,429	1,495	491	1,156	65,880	12.8	4.0
Italy	89,481	14,249	17,127	11,740	945,180	9.5	2.8
The Netherlands	20,382	2,775	4,973	2,761	247,020	8.3	2.2
Portugal	12,053	1,203	1,129	2,064	169,840	7.1	1.9
Spain	121,899	13,302	5,519	6,644	655,640	18.6	3.0
United Kingdom	77,163	18,869	12,123	9,739	873,000	8.9	3.2
European Free Trade Assoc.	69,015	6,779	3,831	9,055	466,400	14.7	3.4
Austria	10,457	1,510	683	989	116,840	8.7	2.1
Finland	14,325	1,818	744	2,939	68,760	20.8	6.9
Norway	18,486	495	496	1,891	67,060	27.6	3.6
Sweden	17,062	1,491	1,200	2,547	117,580	14.5	3.4
Switzerland	8,685	1,465	708	689	96,160	9.0	2.2
Central Europe	140,186	18,107	7,853	30,441	1,408,600	10.0	3.5
Albania	3,353	963	249	546	61,480	5.5	2.5
Bulgaria	21,817	1,972	574	5,813	121,160	18.0	6.4
Czechoslovakia	24,906	3,072	136	9,409	214,560	11.6	5.8
Hungary	12,468	1,046	555	1,323	141,400	8.8	1.7
Poland	50,058	7,024	2,081	7,391	500,000	10.0	2.9
Yugoslavia	27,584	4,030	4,258	5,959	370,000	7.5	2.7
North America							
Total	1,356,618	128,483	201,210	118,704	5,541,600	24.5	4.5
Canada	130,164	13,420	23,120	7,739	391,800	33.2	5.4
Mexico	118,457	9,680	7,985	30,484	1,565,800	7.6	2.6
United States	1,107,997	105,383	170,105	80,481	3,584,000	30.9	5.2

NA = not available; NS&E = natural sciences and engineering

NOTES: Data are compiled from numerous national and international sources and may not be strictly comparable. For Asian countries, detailed national education statistics were reconfigured to the International Standard Classification of Education and Classification of Instructional Programs. For Europe, detailed national education data were available for Austria, France, Germany, Switzerland, and the United Kingdom; these data were standardized. Data for Austria, Finland, Greece, Sweden, the United Kingdom, and the United States are for 1991. Data for Albania, the former Czechoslovakia, and Portugal are for 1989; Belgium data are for 1988. All other country data are for 1990. Degrees in different countries may not be academically equivalent.

[1] Includes degrees in engineering technology.

[2] Social science degrees are not included in this proportion.

[3] Japanese social sciences data are adjusted to delete business administration.

SOURCES: National sources.

See figure 2–1 and text table 2–1.

Science & Engineering Indicators – 1993

Appendix table 2–2.

Ratio of science and engineering degrees to total first university degrees, by region/country: Most current year

Region/country	Total S&E	Natural sciences	Social sciences	Engineering[1]
	Percent			
Asia				
China	61	16	8	37
India	24	20	NA	4
Japan[2]	40	6	14	20
Singapore	43	21	2	20
South Korea	37	14	6	17
Taiwan	43	15	7	21
Europe				
European Community				
Belgium	45	11	23	11
Denmark	29	4	5	20
France	48	18	9	21
Germany	72	19	25	28
Greece	34	15	10	9
Ireland	36	18	6	12
Italy	48	16	19	13
The Netherlands	52	14	24	14
Portugal	36	10	9	17
Spain	21	11	5	5
United Kingdom	51	24	15	12
European Free Trade Assoc.				
Austria	30	14	7	9
Finland	39	13	5	21
Norway	16	3	3	10
Sweden	31	9	7	15
Switzerland	33	17	8	8
Central Europe				
Albania	52	29	7	16
Bulgaria	39	9	3	27
Czechoslovakia	51	12	1	38
Hungary	23	8	4	11
Poland	33	14	4	15
Yugoslavia	52	15	15	22
North America				
Canada	34	10	18	6
Mexico	41	8	7	26
United States	32	10	15	7

NA = not available; S&E = science and engineering

[1] Includes degrees in engineering technology.

[2] Japanese social sciences data are adjusted to delete business administration.

SOURCE: Computed from data in appendix table 2–1.

See figure 2–2.

Science & Engineering Indicators – 1993

Appendix table 2–3.

Participation rate of 22-year-olds in first university degrees in the natural sciences and engineering, by sex and country: Most current year

Country	All first univ. degrees	Degree fields			22-year-olds		
		Natural sciences	Social sciences	Engineering[1]	Total number	With first univ. degree	With NS&E degree
						Percent	
Males							
France	48,724	9,442	3,514	13,080	437,000	11.2	5.2
Germany	88,908	19,098	19,387	36,136	654,000	13.6	8.5
Japan[2]	290,253	20,221	138,708	78,705	915,800	31.7	10.8
Poland	23,015	3,518	788	6,373	252,800	9.1	3.9
South Korea	104,627	15,953	7,579	26,763	447,600	23.4	9.5
Sweden	7,203	896	262	2,018	60,800	11.8	4.8
Taiwan	23,556	4,723	1,167	8,110	190,800	12.4	6.7
United Kingdom	44,239	12,158	6,013	8,572	451,800	9.8	4.6
United States	508,952	61,906	74,900	68,851	1,769,400	28.8	7.4
Females							
France	29,180	4,878	3,477	3,000	419,600	7.0	1.9
Germany	48,468	7,223	14,548	2,152	617,600	7.8	1.5
Japan[2]	109,750	4,932	18,519	2,650	871,600	12.6	0.9
Poland	27,043	3,506	1,293	1,018	240,800	11.2	1.9
South Korea	61,289	7,242	2,632	1,308	411,400	14.9	2.1
Sweden	9,859	595	938	529	58,000	17.0	1.9
Taiwan	19,396	1,810	2,007	840	180,200	10.8	1.5
United Kingdom	35,389	6,711	6,110	1,166	430,400	8.2	1.8
United States	566,284	42,680	87,359	9,973	1,856,000	30.5	1.4

NS&E = natural sciences and engineering

NOTE: Data for Sweden, the United Kingdom, and the United States are for 1991; all others are for 1990.

[1] Includes engineering technology.

[2] Japanese social sciences data are adjusted to delete business administration.

SOURCES: For France, Départment des Statistiques sur l'Énseignement Supérieur, Direction de l'Évaluation et de la Prospective, Ministère de l'Éducation Nationale; for Germany, *Profungen an Hochschulen*, Statistisches Bundesamt, Wiesbaden; for Japan, the *Monbusho Survey of Education*, 1990; for Poland, Office of International Relations Polish Academy of Sciences; for South Korea, *Educational Yearbook*, 1990; for Sweden, SCB Statistics Sweden; for Taiwan, *Educational Statistics of the Republic of China*, 1990; for the United Kingdom, Universities Statistical Record; and for the United States, Science Resources Studies Division, National Science Foundation, *Science and Engineering Degrees: 1960–90*, NSF 92-326 (Washington, DC: NSF, 1992).

See text table 2–2.

Science & Engineering Indicators – 1993

Appendix table 2-4.

Enrollment in higher education, by institution type: 1967–91

	Total	Research I	Research II	Doctorate-granting I	Doctorate-granting II	Comprehensive I	Comprehensive II	Liberal arts I	Liberal arts II	Two-year	Specialized	Other
1967	6,963,687	1,252,675	464,497	520,380	375,788	1,795,160	225,752	175,157	325,988	1,444,588	179,185	204,517
1968	7,571,636	1,294,601	516,285	534,619	397,702	1,980,276	239,268	180,963	328,796	1,725,582	187,641	185,903
1969	8,066,233	1,355,621	532,781	572,510	425,227	2,113,939	248,968	185,706	330,399	1,932,362	193,239	175,481
1970	8,649,368	1,453,796	552,133	612,737	442,678	2,273,712	257,231	190,269	333,270	2,203,141	206,629	123,772
1971	9,025,031	1,415,598	564,082	623,143	448,509	2,391,486	264,495	195,872	331,700	2,457,511	216,231	116,404
1972	9,297,787	1,458,881	570,356	627,054	451,940	2,427,957	263,178	200,314	324,612	2,638,807	223,235	111,453
1973	9,694,297	1,456,187	583,779	631,136	456,404	2,507,079	263,456	202,915	318,000	2,905,469	248,215	121,657
1974	10,321,539	1,503,529	601,667	652,481	471,971	2,606,368	269,854	204,617	323,817	3,307,820	268,886	110,529
1975	11,290,719	1,574,919	636,529	674,637	497,117	2,781,647	289,831	206,391	336,805	3,879,406	301,870	111,567
1976	11,121,426	1,552,599	617,018	674,266	486,717	2,732,182	296,238	206,394	340,071	3,799,530	307,901	108,510
1977	11,418,631	1,533,365	623,592	673,342	506,890	2,815,805	305,743	207,284	350,117	3,966,574	322,567	113,352
1978	11,393,015	1,521,805	622,120	671,316	510,408	2,807,353	307,761	215,219	350,435	3,953,662	333,173	99,763
1979	11,707,126	1,554,573	633,618	681,834	526,387	2,829,076	311,631	214,189	358,104	4,149,845	349,149	98,720
1980	12,234,644	1,590,098	647,720	697,619	540,960	2,919,859	322,911	222,693	367,716	4,472,663	372,887	79,518
1981	12,517,753	1,608,205	645,993	697,499	548,482	2,968,280	326,076	217,914	370,463	4,671,286	387,625	75,930
1982	12,588,520	1,579,207	640,755	695,663	546,829	2,981,208	327,040	212,855	367,047	4,723,213	404,741	109,962
1983	12,633,930	1,601,970	639,000	704,218	545,833	3,011,230	335,724	215,074	374,035	4,694,133	417,203	95,510
1984	12,400,392	1,600,206	632,897	697,964	544,083	2,995,433	334,122	214,286	372,363	4,500,102	420,108	88,828
1985	12,411,945	1,605,569	633,637	696,596	540,983	3,009,974	334,280	214,147	373,348	4,485,270	417,602	100,539
1986	12,670,121	1,628,039	644,079	710,670	540,775	3,038,112	339,250	216,507	383,338	4,584,291	409,971	175,089
1987	12,925,116	1,647,806	656,483	725,092	548,909	3,082,034	351,226	220,246	396,062	4,762,630	402,511	132,117
1988	13,205,540	1,658,852	674,466	744,891	553,767	3,146,337	365,425	224,275	419,909	4,863,479	415,471	138,668
1989	13,621,203	1,669,460	687,091	768,958	564,083	3,249,777	378,557	222,326	437,373	5,085,564	411,049	146,965
1990	13,871,725	1,701,437	689,541	783,397	573,017	3,306,032	386,791	223,554	454,560	5,151,370	427,493	174,533
1991	14,527,881	1,712,773	693,238	796,816	577,285	3,389,319	403,888	224,567	467,908	5,591,000	439,061	232,026

SOURCES: National Center for Education Statistics, U.S. Department of Education, Enrollment Survey, 1991; and Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See figures 2-3 and 2-4.

Science & Engineering Indicators – 1993

Appendix table 2–5.

Number of science and engineering degrees, by degree level and institution type: 1991

Institution type	Total degrees	Total science & engineering	Natural sciences	Math & computer sciences	Social & behavioral sciences	Engineering	Engineering technology[1]
Bachelors degrees							
Total	1,107,997	337,675	65,189	40,194	170,105	62,187	18,294
Research I	222,635	98,918	19,760	7,361	46,410	25,387	1,241
Research II	93,279	33,190	5,991	2,526	17,149	7,524	1,186
Doctorate-granting I	95,749	27,384	4,795	2,940	14,579	5,070	1,400
Doctorate-granting II	69,735	21,987	4,024	2,639	9,416	5,908	1,136
Comprehensive I	406,621	100,524	18,323	16,310	51,988	13,903	8,251
Comprehensive II	52,356	11,671	2,725	2,172	6,353	421	389
Liberal arts I	46,694	22,220	5,179	1,566	15,014	461	27
Liberal arts II	66,403	14,011	3,305	2,417	8,020	269	324
Two-year	3,493	515	78	115	152	170	469
Specialized	42,629	4,866	687	1,781	257	2,141	3,593
Other	4,766	2,299	322	292	767	918	50
Not classified	3,637	90	0	75	0	15	228
Masters degrees							
Total	338,498	78,368	12,682	12,956	28,717	24,013	1,188
Research I	91,729	29,464	5,511	3,795	8,535	11,623	139
Research II	29,589	9,109	1,646	1,265	2,980	3,218	109
Doctorate-granting I	36,141	7,642	1,222	1,365	3,197	1,858	104
Doctorate-granting II	26,469	7,037	1,189	1,284	2,163	2,401	107
Comprehensive I	109,166	18,358	2,471	4,110	8,389	3,388	555
Comprehensive II	11,980	1,452	67	249	1,091	45	27
Liberal arts I	3,751	833	86	53	651	43	0
Liberal arts II	7,452	791	40	23	718	10	0
Two-year	7	0	0	0	0	0	0
Specialized	17,962	2,182	380	720	184	898	94
Other	3,755	1,476	70	86	791	529	53
Not classified	497	24	0	6	18	0	0
Doctoral degrees							
Total	37,451	23,979	10,152	1,837	6,778	5,212	0
Research I	22,735	15,632	6,837	1,292	3,754	3,749	0
Research II	5,714	3,423	1,477	260	1,047	639	0
Doctorate-granting I	4,866	2,387	796	167	1,074	350	0
Doctorate-granting II	2,028	1,270	489	78	364	339	0
Comprehensive I	678	348	143	29	95	81	0
Comprehensive II	22	15	0	0	0	15	0
Liberal arts I	88	33	9	4	20	0	0
Liberal arts II	7	0	0	0	0	0	0
Specialized	875	486	392	1	66	27	0
Other	377	370	9	6	343	12	0
Not classified	61	15	0	0	15	0	0

[1] Engineering technology is not included under "Total science & engineering."

SOURCES: National Center for Education Statistics, U.S. Department of Education, Completion Survey, 1991; and Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See figures 2–5 and 2–6 and text table 2–3.

Appendix table 2–6.

Number of institutions awarding science and engineering degrees, by degree level and institution type: 1991

Institution type	Total degrees	Total science & engineering	Social & behavioral sciences	Natural sciences	Math & computer sciences	Engineering	Engineering technology[1]
Bachelors degrees							
Total	1,814	1,448	1,332	1,256	1,279	388	331
Research I	69	67	67	67	67	62	12
Research II	34	34	34	34	34	28	11
Doctorate-granting I	48	46	46	44	45	30	18
Doctorate-granting II	58	56	51	55	53	34	18
Comprehensive I	424	419	411	401	412	131	167
Comprehensive II	168	167	163	158	158	23	29
Liberal arts I	141	138	138	133	127	16	3
Liberal arts II	413	389	373	332	316	32	30
Two-year	53	20	10	5	10	1	10
Specialized	335	94	29	22	50	22	27
Other	20	15	10	5	6	7	2
Not classified	51	3	0	0	1	2	4
Masters degrees							
Total	1,265	738	598	480	432	255	65
Research I	69	68	68	68	67	63	6
Research II	34	34	34	34	33	29	6
Doctorate-granting I	49	48	48	45	46	27	9
Doctorate-granting II	58	57	48	54	48	30	6
Comprehensive I	384	318	271	202	190	76	31
Comprehensive II	123	50	37	12	16	5	1
Liberal arts I	54	30	21	17	9	2	0
Liberal arts II	156	42	37	8	3	1	0
Two-year	2	0	0	0	0	0	0
Specialized	279	69	17	36	15	17	5
Other	32	20	16	4	4	5	1
Not classified	25	2	1	0	1	0	0
Doctoral degrees							
Total	355	299	221	257	156	167	0
Research I	71	71	69	71	67	65	0
Research II	34	34	34	34	31	27	0
Doctorate-granting I	49	48	47	45	30	26	0
Doctorate-granting II	57	53	39	44	19	28	0
Comprehensive I	60	36	11	27	4	12	0
Comprehensive II	3	1	0	0	0	1	0
Liberal arts I	6	4	3	2	1	0	0
Liberal arts II	2	0	0	0	0	0	0
Specialized	59	38	7	32	1	5	0
Other	13	13	10	2	3	3	0
Not classified	1	1	1	0	0	0	0

[1] Engineering technology is not included under "Total science & engineering."

SOURCES: National Center for Education Statistics, U.S. Department of Education, Completion Survey, 1991; and Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See text table 2–3.

Science & Engineering Indicators – 1993

Appendix table 2–7.

Proportion of undergraduate instruction provided by various faculty members, by field and institution type: 1990

	All institutions	Research I & II	Doctorate–granting I & II	Comprehensive I & II	Liberal arts I & II
	Percent				
Geology					
Full-time faculty	79	66	71	81	92
Part-time faculty	9	4	7	13	5
Teaching assistant	12	30	21	5	2
Other faculty	0	0	1	0	0
Physics					
Full-time faculty	85	59	68	89	90
Part-time faculty	7	4	7	8	6
Teaching assistant	8	36	25	3	3
Other faculty	0	0	0	0	1
Sociology					
Full-time faculty	82	68	78	83	85
Part-time faculty	15	11	15	17	14
Teaching assistant	2	20	6	0	0
Other faculty	1	1	0	0	0

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Survey on Undergraduate Education in Geology* (Washington, DC: NSF, 1992); SRS, *Survey on Undergraduate Education in Physics* (Washington, DC: NSF, 1992); and SRS, *Survey on Undergraduate Education in Sociology* (Washington, DC: NSF, 1992).

See figure 2–7 and text table 2–4.

Science & Engineering Indicators – 1993

Appendix table 2–8.

Total undergraduate enrollments, by race/ethnicity/citizenship and sex: 1976–91

Race, ethnicity, and citizenship	1976	1980	1982	1984	1986	1988	1990	1991
	Thousands							
All students								
Total	9,419	10,469	10,789	10,611	10,798	11,304	11,959	12,439
White	7,741	8,481	8,676	8,484	8,558	8,907	9,273	9,508
Asian	169	249	308	343	393	437	501	559
Black	943	1,019	1,020	995	996	1,039	1,147	1,229
Hispanic	353	433	480	495	563	631	725	804
Native American	76	84	88	84	90	93	95	106
Foreign citizen	143	210	223	216	205	205	219	234
Men								
Total	4,897	4,997	5,140	5,002	5,018	5,134	5,339	5,571
White	4,052	4,055	4,134	4,005	3,978	4,054	4,166	4,273
Asian	91	129	163	182	207	224	247	281
Black	431	428	425	405	403	408	463	478
Hispanic	192	211	232	234	264	287	318	361
Native American	35	35	37	35	37	36	40	44
Foreign citizen	96	140	149	142	130	124	129	133
Women								
Total	4,522	5,472	5,649	5,608	5,781	6,170	6,524	6,868
White	3,688	4,426	4,542	4,479	4,580	4,853	5,066	5,235
Asian	78	120	145	161	186	212	238	277
Black	513	591	595	590	594	631	684	751
Hispanic	161	222	248	261	299	344	384	443
Native American	35	43	45	43	47	50	55	62
Foreign citizen	47	70	74	74	74	81	97	101

SOURCES: National Center for Education Statistics (NCES), U.S. Department of Education, *Digest of Education Statistics*, NCES 92-097 (Washington, DC: Government Printing Office, 1992); NCES, *Trends in Racial/Ethnic Enrollment in Higher Education: Fall 1982 Through Fall 1991*, NCES 93-448 (Washington, DC: GPO, 1993); and NCES, unpublished tabulations.

Science & Engineering Indicators – 1993

Appendix table 2–9.

Undergraduate enrollment in engineering and engineering technology programs: 1979–92

Enrollment	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Engineering programs														
Total	366,299	397,344	420,402	435,330	441,205	429,499	420,864	407,657	392,198	385,412	378,277	380,287	379,977	382,525
Total full time	340,488	365,117	387,577	403,390	406,144	394,635	384,191	369,520	356,998	346,169	338,529	338,842	339,397	344,126
Freshman	103,724	110,149	115,280	115,303	109,638	105,249	103,225	99,238	95,453	98,009	95,420	94,346	93,002	93,427
Sophomore	78,594	84,982	87,519	89,785	89,515	83,946	79,627	76,195	73,317	71,030	71,267	72,204	71,257	71,644
Junior	74,928	80,024	86,633	90,541	91,233	89,509	84,875	80,386	77,085	73,761	70,483	72,666	73,516	74,871
Senior	77,823	84,442	92,414	102,055	109,036	109,695	110,305	107,773	104,003	97,614	94,465	92,989	94,683	98,235
Fifth year	5,419	5,520	5,731	5,706	6,722	6,236	6,159	5,928	7,140	5,755	6,894	6,637	6,939	5,949
Total part time	25,811	32,227	32,825	31,940	35,061	34,864	36,673	38,137	35,200	39,243	39,748	41,445	40,580	38,399
Total number of schools	286	287	286	286	292	289	297	311	316	320	323	328	336	337
ABET-accredited schools[1]	239	246	250	249	258	258	264	270	277	281	284	289	303	309
Engineering technology programs														
Total	NA	NA	191,152	176,133	163,226	157,897	123,571	137,390	128,501	131,704	127,687	123,217	127,135	124,736
Total full time	NA	NA	134,444	120,342	112,745	111,446	83,038	90,536	80,600	79,624	76,179	72,390	75,340	73,245
First year	NA	NA	65,893	59,339	53,032	46,806	34,389	39,177	32,685	33,477	32,225	30,178	31,302	30,543
Second year	NA	NA	40,774	36,807	33,799	31,716	23,293	25,612	22,906	21,852	21,627	20,586	20,815	21,081
Full-time associates	NA	NA	872	797	925	1,165	466	657	1,404	1,760	1,810	1,603	2,221	2,336
BA of engineering tech third and later years	NA	NA	26,905	23,399	24,989	31,759	24,890	25,090	23,605	22,535	20,517	20,023	21,002	19,285
Total part time	NA	NA	56,708	55,791	50,481	46,451	40,533	46,854	47,901	52,080	51,508	50,827	51,795	51,491
Number of schools	NA	NA	NA	NA	NA	NA	200	257	291	310	286	303	302	298

NA = not available

[1] Schools with at least one curriculum accredited by the Accreditation Board of Engineering and Technology (ABET).

SOURCE: Engineering Manpower Commission, American Association of Engineering Societies, *Engineering and Technology Enrollments, Fall 1991, Parts I and II* (Washington, DC: 1992).

Science & Engineering Indicators – 1993

Appendix table 2–10.
Undergraduate enrollment in engineering, by sex and race/ethnicity: 1979–92

Sex and race/ethnicity	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
							Number of students							
Total	366,299	397,344	420,402	435,330	441,205	429,499	420,864	407,657	392,198	385,412	378,277	380,287	379,977	382,525
Sex														
Male	321,868	345,482	361,133	368,750	372,374	362,800	354,612	344,999	331,917	325,024	318,067	309,744	313,961	313,697
Female	44,431	51,862	59,269	66,580	68,831	66,699	66,252	62,658	60,281	60,388	60,210	60,781	63,258	66,065
Race/ethnicity														
White	302,566	326,913	343,649	356,750	354,329	340,374	323,899	315,861	296,749	288,415	281,948	288,732	271,906	270,942
Asian	12,243	12,772	15,815	17,570	23,007	25,449	28,767	30,201	32,795	34,051	33,360	30,898	37,803	38,480
Underrepresented minorities	28,729	31,531	34,353	35,960	37,432	37,557	39,657	37,240	38,640	40,389	41,338	41,169	48,692	51,517
Black	15,842	17,606	18,911	19,400	19,698	19,204	19,819	18,459	19,142	20,405	21,013	20,833	24,563	25,722
Hispanic	12,068	12,905	14,359	15,320	16,462	17,075	18,598	17,586	18,253	18,700	19,007	18,873	22,441	23,863
Native American	819	1,020	1,083	1,240	1,272	1,278	1,240	1,195	1,245	1,284	1,318	1,463	1,688	1,932
Foreign citizen	22,761	26,128	26,585	25,050	26,437	26,119	28,541	24,355	24,014	22,557	21,631	19,488	21,576	21,586
							Percentage of students							
Sex														
Male	87.9	86.9	85.9	84.7	84.4	84.5	84.3	84.6	84.6	84.3	84.1	81.5	82.6	82.0
Female	12.1	13.1	14.1	15.3	15.6	15.5	15.7	15.4	15.4	15.7	15.9	16.0	16.6	17.3
Race/ethnicity														
White	82.6	82.3	81.7	81.9	80.3	79.2	77.0	77.5	75.7	74.8	74.5	75.9	71.6	70.8
Asian	3.3	3.2	3.8	4.0	5.2	5.9	6.8	7.4	8.4	8.8	8.8	8.1	9.9	10.1
Underrepresented minorities	7.8	7.9	8.2	8.3	8.5	8.7	9.4	9.1	9.9	10.5	10.9	10.8	12.8	13.5
Black	4.3	4.4	4.5	4.5	4.5	4.5	4.7	4.5	4.9	5.3	5.6	5.5	6.5	6.7
Hispanic	3.3	3.2	3.4	3.5	3.7	4.0	4.4	4.3	4.7	4.9	5.0	5.0	5.9	6.2
Native American	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5
Foreign citizen	6.2	6.6	6.3	5.8	6.0	6.1	6.8	6.0	6.1	5.9	5.7	5.1	5.7	5.6

SOURCE: Engineering Manpower Commission, American Association of Engineering Societies, *Engineering and Technology Enrollments, Fall 1991, Parts I and II* (Washington, DC: 1992).

See figure 2–8.

Science & Engineering Indicators – 1993

Appendix table 2–11.

Freshman choice of major in broad science and engineering fields, by race/ethnicity and sex: 1972–92

(page 1 of 3)

Sex and field	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	Percent																				
White students																					
All students																					
Total S&E	29.4	33.8	33.1	32.6	32.3	28.9	30.3	29.4	30.3	29.6	31.3	31.0	31.2	30.0	28.8	27.2	28.0	28.1	28.3	29.6	30.5
Natural science	8.3	12.3	12.0	11.9	11.8	9.1	8.7	7.5	7.1	6.9	6.7	7.0	6.7	6.2	6.0	6.1	6.6	6.1	6.8	7.3	8.2
Math/comp. science	3.0	2.4	1.9	1.7	1.5	1.1	1.3	0.9	1.0	0.9	1.0	1.1	1.4	1.4	1.2	1.0	0.9	0.9	0.9	0.8	0.8
Social science	8.5	8.2	7.5	6.6	6.2	5.8	5.7	5.9	5.5	5.1	4.6	4.8	5.8	5.7	6.0	6.4	6.7	6.5	7.0	6.4	7.4
Engineering	6.3	6.0	7.6	8.7	8.7	9.5	10.3	10.6	11.5	10.7	11.7	11.1	11.3	11.0	10.0	8.8	8.7	9.2	8.8	10.3	9.6
Male																					
Total S&E	35.6	41.6	40.5	40.8	40.0	36.1	38.0	36.3	38.3	38.1	40.2	40.4	38.9	37.3	35.5	33.9	33.8	35.9	35.5	35.7	36.4
Natural science	11.0	16.4	15.1	14.9	14.4	10.7	10.8	8.7	8.2	8.4	7.2	8.4	7.8	7.2	7.1	7.0	7.6	7.6	7.9	7.9	9.0
Math/comp. science	3.2	2.7	2.3	1.8	1.8	1.3	1.4	0.9	0.9	0.9	1.0	1.1	1.1	1.1	1.4	1.2	0.9	1.0	0.7	0.8	0.9
Social science	5.7	5.2	4.8	4.1	3.9	3.4	2.6	3.2	2.9	3.2	2.7	2.9	3.6	3.3	2.8	3.6	3.4	3.4	4.4	3.4	4.4
Engineering	11.8	11.0	13.7	15.2	15.1	16.7	18.2	18.8	20.3	18.8	20.2	19.5	19.6	19.2	17.5	16.0	15.8	17.2	16.1	17.9	16.9
Female																					
Total S&E	22.7	24.9	24.7	24.5	24.1	21.7	23.0	22.8	22.7	21.9	23.0	22.7	23.0	23.2	22.3	21.8	23.2	21.9	23.2	24.2	25.2
Natural science	5.5	8.2	8.7	8.7	9.2	7.4	6.7	6.4	6.0	5.5	6.2	5.8	5.7	5.4	5.0	5.3	5.6	4.8	5.9	6.9	7.4
Math/comp. science	2.8	2.0	1.6	1.7	1.3	1.0	1.2	0.8	1.0	0.9	1.0	1.1	1.7	1.6	0.9	0.8	0.8	0.8	1.0	0.8	0.8
Social science	11.7	11.3	10.4	9.2	8.5	8.4	8.6	8.5	7.8	6.9	6.4	6.6	7.9	7.9	9.0	9.0	9.7	9.1	9.3	9.2	10.2
Engineering	0.4	0.8	1.1	1.7	2.2	2.0	2.6	2.8	3.4	3.2	3.5	3.4	3.5	3.3	3.0	2.4	2.3	2.5	2.4	3.4	3.0
Asian students																					
All students																					
Total S&E	41.6	48.6	49.7	50.3	49.6	41.9	45.6	48.6	48.4	47.6	49.6	50.1	48.7	51.1	46.2	47.0	44.5	43.0	42.8	44.2	43.6
Natural science	10.6	25.5	22.3	22.2	20.2	14.3	15.9	12.9	11.9	12.5	12.9	14.9	15.2	16.0	14.5	14.8	14.5	12.0	12.6	14.9	16.0
Math/comp. science	4.3	3.6	3.2	2.6	2.1	1.5	1.6	1.7	0.7	1.4	0.9	1.7	1.2	1.2	1.2	0.9	0.9	0.9	0.9	0.9	0.8
Social science	7.6	4.5	6.8	5.6	5.6	3.2	3.9	3.7	3.3	3.7	3.5	3.9	3.7	3.7	4.1	5.0	5.6	5.7	5.8	5.0	5.4
Engineering	14.3	11.1	13.4	15.7	17.8	18.3	19.3	25.5	25.5	23.2	23.1	21.6	21.6	24.2	20.6	19.7	17.1	19.3	16.8	17.3	16.5
Male																					
Total S&E	48.3	58.0	60.5	58.5	60.5	54.1	55.2	58.8	59.2	58.2	59.4	59.6	60.1	60.2	56.1	55.7	52.8	51.5	52.3	54.3	51.3
Natural science	11.5	29.3	26.5	23.9	21.0	15.9	15.7	14.4	13.5	13.2	14.4	16.8	16.5	15.7	14.8	14.4	15.3	12.8	14.1	15.5	16.2
Math/comp. science	3.8	2.5	3.5	2.6	2.0	1.6	1.8	1.4	0.6	1.2	0.9	1.3	1.1	1.2	1.0	0.7	0.9	0.6	0.9	0.9	1.0
Social science	3.8	2.7	4.2	4.2	4.0	2.3	3.4	2.2	2.1	2.1	2.1	2.1	2.7	2.8	2.2	2.8	3.8	3.2	3.6	3.3	3.7
Engineering	24.3	18.5	22.0	24.3	29.7	30.0	30.5	37.2	38.1	36.5	34.9	32.2	32.9	34.8	32.7	31.0	26.4	30.1	26.7	28.0	25.7
Female																					
Total S&E	32.5	37.8	37.3	39.7	38.0	28.7	36.2	38.0	34.7	36.1	39.8	39.5	37.4	40.4	36.3	37.6	36.1	34.7	33.6	34.5	36.1
Natural science	9.3	21.1	17.2	19.9	19.3	12.5	16.0	11.1	10.0	11.8	11.5	13.0	13.9	16.2	14.2	15.3	13.6	11.2	11.1	14.4	15.7
Math/comp. science	4.8	5.0	2.8	2.7	2.2	1.3	1.4	2.1	0.9	1.6	1.0	2.0	1.2	1.2	1.5	1.1	0.9	1.1	0.8	0.8	0.7
Social science	12.4	6.6	10.0	7.3	7.3	4.2	4.4	5.3	4.9	5.2	5.1	5.9	4.6	4.7	6.0	7.4	7.5	8.4	7.9	6.7	7.0
Engineering	2.1	2.4	3.0	5.0	4.9	5.2	7.9	12.6	10.6	9.5	10.5	10.1	10.2	12.3	8.2	7.7	6.7	7.5	7.4	6.7	7.3

(continued)

Appendix table 2–11.

Freshman choice of major in broad science and engineering fields, by race/ethnicity and sex 1972–92

(page 2 of 3)

Sex and field	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	Percent																				
Black students																					
All students																					
Total S&E	27.3	33.7	31.1	29.5	31.2	28.6	30.4	29.0	30.1	30.4	33.0	31.1	28.4	29.3	27.6	30.4	30.6	30.7	30.9	34.8	36.4
Natural science	4.0	8.8	7.9	6.6	8.2	5.3	5.6	4.8	4.4	4.9	5.1	4.8	5.3	4.7	4.4	4.7	4.4	5.2	5.1	6.1	7.2
Math/comp. science	2.1	2.2	1.4	0.8	0.8	0.7	0.8	0.6	0.7	0.8	0.9	0.6	0.6	0.7	0.6	0.6	0.6	0.4	0.5	0.6	0.7
Social science	13.3	12.6	11.0	11.6	10.8	10.1	10.2	8.9	7.6	5.9	5.6	5.4	5.9	5.4	6.9	7.2	9.3	8.0	8.7	7.8	8.1
Engineering	4.5	4.1	5.5	5.9	6.6	7.8	8.2	8.8	10.3	9.9	11.3	8.7	7.4	9.5	8.4	10.4	8.5	9.2	8.8	12.4	12.7
Male																					
Total S&E	30.8	37.2	35.6	33.1	34.7	33.6	34.0	33.4	35.2	36.1	38.5	35.3	33.2	33.5	31.6	34.8	33.7	33.4	32.7	39.4	41.2
Natural science	4.9	11.0	9.0	7.3	9.3	6.3	5.6	5.1	4.5	5.2	5.2	5.4	5.3	3.9	4.3	4.9	4.5	4.2	4.9	5.1	6.8
Math/comp. science	1.8	2.2	1.8	0.9	0.8	0.7	1.0	0.6	0.8	0.8	0.9	0.8	0.5	0.8	0.8	0.7	0.6	0.4	0.4	0.6	0.6
Social science	8.9	8.0	7.7	8.2	6.9	6.3	5.9	5.0	4.3	3.0	3.4	3.1	4.4	2.6	4.6	4.3	5.4	4.3	4.5	5.0	5.1
Engineering	9.9	8.8	10.6	11.4	12.6	15.0	15.5	16.3	18.5	17.2	19.3	15.4	12.9	16.0	14.8	17.5	15.0	15.9	14.8	21.4	21.1
Female																					
Total S&E	25.1	30.8	26.7	26.8	28.1	24.5	28.0	25.8	26.5	26.6	28.9	27.6	24.8	26.4	24.8	27.2	28.6	29.1	30.2	32.1	33.4
Natural science	3.2	7.1	6.9	6.1	7.5	4.4	5.7	4.6	4.4	4.8	4.9	4.5	5.3	5.3	4.5	4.7	4.3	5.7	5.2	6.7	7.5
Math/comp. science	2.3	2.2	1.1	0.8	0.7	0.6	0.7	0.5	0.7	0.8	0.9	0.4	0.7	0.6	0.5	0.6	0.6	0.5	0.6	0.6	0.8
Social science	16.6	16.1	13.6	14.1	13.6	12.9	13.0	11.5	9.9	7.9	7.1	6.9	6.9	7.4	8.4	9.0	11.6	10.3	11.3	9.5	10.1
Engineering	0.4	0.7	1.6	1.8	2.3	2.4	3.3	3.7	4.7	4.6	5.8	4.2	3.7	4.9	4.4	5.9	4.4	5.1	4.9	6.7	6.8
Hispanic students																					
All students																					
Total S&E	32.7	37.7	40.5	39.0	36.0	34.0	29.7	30.1	37.5	34.4	33.5	34.9	32.8	38.0	35.0	34.3	31.1	33.3	34.0	30.6	34.4
Natural science	5.5	12.8	13.7	13.3	10.9	7.0	6.7	7.5	8.5	8.1	6.4	8.2	7.7	8.6	8.4	7.8	6.4	7.2	7.4	7.3	8.5
Math/comp. science	2.4	2.0	2.0	1.8	1.0	0.8	0.8	0.3	0.7	0.5	0.9	1.1	0.7	0.7	0.8	0.5	0.5	0.6	0.8	0.3	0.7
Social science	13.2	11.0	12.7	10.7	10.9	11.2	8.5	7.9	7.8	5.5	5.4	5.7	5.9	9.4	7.4	8.7	8.9	9.1	8.4	6.8	9.0
Engineering	7.4	5.9	7.7	7.2	8.2	8.9	9.0	8.7	12.8	14.1	11.9	12.6	10.2	12.9	12.1	11.3	9.0	10.5	10.9	10.2	10.1
Male																					
Total S&E	35.6	42.7	46.3	42.9	40.2	39.7	35.0	36.4	41.9	40.5	39.4	40.4	41.2	44.8	41.7	40.5	35.2	38.8	39.1	35.0	37.3
Natural science	6.8	14.1	16.8	15.7	13.2	7.5	7.4	9.2	8.8	7.5	7.4	8.7	8.4	9.6	8.5	8.4	7.3	7.7	8.8	7.1	9.0
Math/comp. science	2.6	2.3	2.0	2.1	1.3	1.3	1.3	0.5	0.5	0.7	0.9	1.4	0.6	0.8	1.0	0.8	0.7	0.7	0.7	0.5	0.7
Social science	7.8	8.4	7.4	6.9	5.4	8.2	4.3	4.8	3.3	1.8	3.0	3.3	5.0	5.2	3.8	6.1	5.6	5.6	3.8	4.0	5.1
Engineering	13.9	10.8	14.7	11.5	14.4	16.6	15.9	16.1	21.0	23.6	19.4	19.8	17.3	21.3	21.9	19.4	15.9	18.3	19.5	17.0	17.0
Female																					
Total S&E	29.2	33.0	34.9	34.7	31.7	28.5	24.8	25.3	34.0	28.3	28.1	30.2	25.9	32.2	29.6	29.5	27.8	29.5	30.0	26.6	31.4
Natural science	4.0	11.3	10.5	10.4	8.5	6.6	6.2	6.1	8.2	8.6	5.6	7.7	7.2	7.8	8.3	7.3	5.7	6.8	6.3	7.4	8.2
Math/comp. science	2.2	1.7	2.0	1.3	0.7	0.3	0.4	0.3	0.9	0.3	0.9	0.8	0.7	0.5	0.6	0.3	0.4	0.4	0.9	0.2	0.6
Social science	19.5	13.9	18.1	15.3	16.9	13.8	12.6	10.5	11.9	9.0	7.7	7.9	6.6	12.9	10.2	10.8	11.5	12.0	12.0	9.5	12.4
Engineering	0.0	0.3	0.6	1.9	1.4	2.2	2.3	2.7	5.5	5.4	5.0	6.3	4.3	6.0	4.2	4.5	3.5	4.2	4.3	3.8	4.1

(continued)

Appendix table 2–11.

Freshman choice of major in broad science and engineering fields, by race/ethnicity and sex: 1972–92

(page 3 of 3)

Sex and field	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	Percent																				
Native American students																					
All students																					
Total S&E	30.5	33.7	37.9	35.0	31.6	31.2	32.3	28.7	35.3	27.3	29.3	27.4	26.3	26.5	29.6	31.0	30.8	32.8	30.9	31.1	31.3
Natural science	7.9	12.3	15.4	13.1	7.5	8.2	8.1	5.8	8.0	6.1	6.0	5.3	5.0	7.1	6.0	6.9	8.4	9.3	8.3	7.9	8.5
Math/comp. science	2.5	2.3	1.2	1.0	1.1	1.5	1.1	0.1	0.9	0.4	1.1	0.6	0.6	0.5	0.8	1.0	0.6	0.5	0.4	0.3	0.4
Social science	11.4	10.6	10.1	8.5	12.6	8.6	8.0	9.1	6.8	5.5	6.3	6.3	7.9	6.5	7.2	7.5	7.1	6.0	9.2	8.1	8.5
Engineering	5.7	4.3	6.8	7.4	6.6	8.1	10.2	9.5	13.4	10.1	10.6	8.9	7.7	6.7	10.0	10.1	8.3	10.6	7.9	9.9	9.2
Male																					
Total S&E	36.2	41.9	45.5	39.7	37.7	36.7	36.4	35.2	40.7	38.4	34.4	34.4	31.8	32.1	39.2	39.5	37.1	38.2	34.2	36.7	37.3
Natural science	10.4	17.8	20.0	15.8	14.9	11.6	10.1	10.9	9.0	7.3	7.0	8.7	8.2	9.6	9.1	9.9	9.3	7.4	10.6	8.4	8.9
Math/comp. science	3.3	2.2	1.4	1.2	1.0	2.4	0.7	0.2	1.1	0.7	1.5	0.6	0.1	0.8	0.7	0.8	0.7	0.4	0.9	0.3	0.3
Social science	7.8	6.3	5.8	4.8	4.3	5.4	3.1	3.4	3.8	4.1	1.2	3.8	3.1	4.1	5.4	4.7	4.4	4.7	4.8	5.0	6.3
Engineering	11.2	8.6	13.8	12.3	11.9	11.5	16.9	15.6	19.1	19.5	18.4	14.9	14.0	11.4	17.4	18.3	15.5	17.2	14.0	18.2	15.7
Female																					
Total S&E	25.7	27.1	30.6	30.6	25.8	26.4	28.1	23.2	30.4	17.3	25.2	21.9	21.7	21.2	21.9	24.6	25.3	29.3	28.0	26.8	26.4
Natural science	5.7	7.5	11.6	10.4	10.2	5.7	6.0	7.5	4.3	3.8	5.7	4.3	7.7	3.9	5.7	5.5	5.4	5.0	8.1	7.9	8.2
Math/comp. science	1.9	2.4	1.1	0.7	1.3	0.7	1.5	0.0	0.7	0.1	0.6	0.7	1.0	0.2	0.8	1.2	0.5	0.6	0.1	0.3	0.5
Social science	14.6	14.3	13.6	12.2	10.7	11.1	12.9	8.1	12.6	7.9	10.2	6.5	6.6	9.8	6.5	8.6	11.6	12.5	10.8	10.1	10.1
Engineering	0.5	0.5	1.0	2.6	1.1	4.7	3.6	4.1	7.0	1.8	3.8	3.7	1.9	2.6	4.1	3.6	2.6	5.9	3.4	3.3	4.0

S&E = science and engineering

SOURCE: Higher Education Research Institute, University of California at Los Angeles, *Survey of the American Freshman: National Norms* (Los Angeles: 1992), unpublished tabulations.

Science & Engineering Indicators – 1993

Appendix table 2–12.

Freshman choice of major in subfields of science and engineering, by race/ethnicity: 1972–92

Field	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
											Percent										
White students																					
Total S&E	90.0	90.5	90.0	89.0	87.6	87.1	87.9	86.2	85.9	87.4	85.2	85.7	85.9	84.1	84.1	83.2	81.1	82.0	78.9	76.9	79.0
Physics	94.0	92.2	91.7	91.8	89.5	90.5	91.4	89.9	90.0	89.9	87.9	89.5	89.0	85.1	87.4	87.3	87.7	86.0	86.5	82.5	83.8
Biology	93.3	91.8	90.9	90.5	88.8	89.4	89.0	88.1	88.3	87.8	85.8	85.2	84.2	83.8	82.7	81.8	79.9	80.8	77.8	76.2	78.4
Social science	86.2	87.6	86.8	84.5	84.0	83.1	83.5	83.3	83.4	87.0	84.7	84.8	85.4	87.2	84.4	85.0	81.9	83.6	78.2	77.8	80.0
Engineering	91.1	92.2	91.5	90.8	86.8	88.0	89.2	86.7	86.1	87.5	85.8	87.3	87.8	83.4	84.1	81.6	80.8	81.2	79.3	76.1	77.2
Asian students																					
Total S&E	1.2	1.2	1.5	1.8	1.8	1.8	1.8	2.2	2.2	2.0	2.5	2.8	2.7	4.4	4.6	4.8	5.2	4.8	5.3	6.0	5.8
Physics	1.3	1.5	2.0	2.1	2.3	2.7	2.3	2.8	2.3	2.8	3.6	3.5	4.0	6.1	5.4	5.0	5.5	4.4	5.4	5.8	5.9
Biology	1.2	1.7	1.8	2.4	2.1	2.1	2.3	2.2	2.5	2.5	3.2	4.2	3.9	6.6	7.1	7.7	8.6	7.0	7.7	9.2	8.4
Social science	0.7	0.5	0.8	1.0	0.9	1.0	1.0	0.9	1.1	1.1	1.6	1.4	1.6	2.5	2.5	2.8	3.5	3.1	3.7	4.2	3.8
Engineering	1.7	1.5	1.7	2.1	2.4	2.4	2.2	3.1	2.9	2.7	3.0	3.4	3.5	5.7	5.8	6.0	6.5	6.4	6.4	6.7	6.9
Black students																					
Total S&E	7.5	7.0	6.7	7.6	8.5	8.6	8.2	9.1	9.7	8.6	10.4	9.7	9.5	9.4	8.6	9.6	10.6	10.3	12.1	13.2	11.2
Physics	3.9	5.2	5.0	4.9	6.3	5.0	4.7	5.8	6.0	5.6	6.9	6.0	5.6	7.7	5.3	5.7	5.0	7.2	5.3	8.6	7.2
Biology	4.6	5.1	5.2	5.3	6.9	6.2	6.3	6.7	7.0	7.1	8.9	7.9	9.5	6.8	6.8	7.6	7.8	9.0	10.2	10.0	8.9
Social science	11.6	10.2	10.3	12.2	12.5	12.8	12.7	12.7	12.4	10.1	10.7	11.9	11.4	8.9	10.3	9.7	11.5	10.2	14.1	13.7	11.5
Engineering	5.4	4.9	5.2	5.9	6.8	7.3	6.7	7.7	8.7	7.6	9.4	7.6	7.0	8.5	7.4	9.8	9.5	9.4	10.6	13.4	12.2
Hispanic students																					
Total S&E	1.1	0.9	1.3	1.5	1.3	1.9	1.4	2.0	1.6	1.3	1.8	1.3	1.2	1.6	2.1	1.9	2.3	2.3	2.5	2.7	4.1
Physics	0.5	0.8	0.9	1.0	1.3	0.6	1.1	1.5	1.2	1.3	1.0	0.7	1.2	1.0	1.2	1.4	1.8	1.7	1.8	2.1	2.6
Biology	1.3	1.5	1.8	1.9	1.9	1.9	1.9	2.2	1.9	2.6	2.0	1.8	1.9	1.8	2.2	2.2	2.7	2.2	2.5	2.8	4.2
Social science	1.4	1.1	1.5	2.1	1.8	2.6	2.0	2.6	2.1	1.4	2.0	1.5	1.2	1.5	2.1	1.9	2.5	2.4	2.7	2.9	4.9
Engineering	1.1	0.9	1.2	1.0	1.1	1.5	1.3	1.6	1.3	1.3	1.7	1.3	1.1	1.5	2.1	1.9	2.2	2.2	2.5	2.5	3.9
Native American students																					
Total S&E	1.1	0.9	0.9	0.8	0.9	0.7	0.7	0.8	0.8	0.9	0.9	1.0	0.9	0.9	0.9	1.0	0.9	1.0	1.3	1.7	1.8
Physics	1.1	0.8	0.9	0.7	1.2	0.5	0.6	1.0	0.6	0.8	0.9	1.3	0.6	0.8	1.1	1.1	0.8	0.9	2.1	1.5	1.5
Biology	1.0	0.9	1.1	0.9	1.0	0.8	0.7	0.7	0.8	0.8	1.0	1.1	1.5	1.2	1.0	1.1	1.0	0.9	1.6	1.8	1.8
Social science	1.3	1.1	1.0	1.0	1.0	0.8	0.8	0.8	0.9	1.1	0.9	1.4	0.6	0.9	1.0	1.0	0.9	1.2	1.3	1.9	1.8
Engineering	0.8	0.7	0.7	0.7	0.7	0.5	0.6	0.7	0.7	0.9	0.9	0.9	0.7	0.6	0.9	1.0	0.8	1.0	1.1	1.5	1.6

S&E = science and engineering

SOURCE: Higher Education Research Institute, University of California at Los Angeles, Survey of the American Freshman: National Norms (Los Angeles: 1992), unpublished tabulations.

See figure 2–9.

Appendix table 2–13.
Planned college majors of National Merit Scholars: 1982–92
(page 1 of 2)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Total											
Male	2,830	2,851	3,026	3,197	3,247	3,041	2,987	3,198	3,006	3,103	3,192
Female	1,740	1,831	1,815	1,729	1,602	1,595	1,628	1,517	1,767	1,762	1,903
Engineering											
Male	969	1,068	1,039	1,112	1,142	1,030	997	1,049	952	1,098	1,185
Female	336	361	363	288	247	251	245	237	247	248	302
Natural sciences											
Male	973	986	1,121	1,127	1,060	1,002	979	1,009	1,045	974	1,008
Female	544	656	603	578	483	478	476	422	521	544	606
Astronomy											
Male	19	14	20	17	22	28	28	22	23	18	9
Female	10	2	9	7	10	5	5	6	6	10	9
Biochemistry											
Male	65	62	70	69	61	80	79	59	61	77	82
Female	56	65	77	72	45	63	53	53	63	58	85
Biosciences, unspecified											
Male	85	72	85	113	107	69	84	66	68	67	86
Female	103	122	131	121	115	79	95	84	101	91	107
Biology, botany, zoology											
Male	61	42	47	46	56	75	73	60	93	86	82
Female	71	96	70	88	80	88	91	86	102	139	151
Biophysics											
Male	4	8	12	13	5	10	5	9	6	5	13
Female	5	5	4	3	1	2	1	4	2	0	3
Chemistry											
Male	77	64	87	98	87	71	91	79	75	89	103
Female	47	64	48	60	48	45	37	42	51	50	61
Computer sciences											
Male	244	325	326	264	219	186	180	221	200	183	201
Female	104	135	92	49	26	29	29	19	28	28	24
Earth sciences											
Male	22	16	10	13	10	9	5	12	12	16	16
Female	12	16	8	12	5	7	9	5	6	9	15
Math and statistics											
Male	118	103	139	145	154	142	104	155	149	147	126
Female	65	63	91	74	73	69	68	50	74	70	68
Physical sciences, unspecified											
Male	66	65	71	84	74	74	107	86	87	74	81
Female	33	29	37	36	29	43	49	26	45	37	41
Physics											
Male	212	215	254	265	265	258	223	240	271	212	209
Female	38	59	36	56	51	48	39	47	43	52	42
Health sciences											
Male	357	344	359	386	384	312	249	290	228	315	351
Female	325	315	307	300	274	234	236	212	244	241	307
Social sciences											
Male	210	206	231	244	303	320	346	375	346	295	279
Female	179	182	195	222	223	285	298	311	346	331	325

(continued)

Appendix table 2–13.

Planned college majors of National Merit Scholars: 1982–92

(page 2 of 2)

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Business											
Male	135	100	114	157	170	171	183	206	183	170	136
Female	138	135	139	135	147	116	136	104	109	111	88
Arts											
Male	72	52	70	80	70	65	70	73	82	83	73
Female	78	72	78	71	80	76	76	49	78	85	77
Other											
Male	114	95	92	91	118	141	163	196	170	168	160
Female	140	110	130	135	148	155	161	182	222	202	198
Undecided											
Male	75	57	82	82	102	306	439	434	460	472	504
Female	67	51	93	78	82	298	285	321	368	333	401

SOURCE: National Merit Scholarship Corporation, *Annual Report* (Evanston, IL: Ongoing annual series). Used with permission.

See figure 2–10.

Science & Engineering Indicators – 1993

Appendix table 2–14.

Freshmen reporting need for remedial work in science or mathematics, by intended major, sex, and race/ethnicity: 1992

Intended major	All students	Sex		Race/ethnicity				
		Male	Female	White	Asian	Black	Hispanic	Native American
	Percent							
S&E								
Science	8.9	6.9	11.2	7.5	16.1	20.4	20.8	17.4
Math	20.6	15.4	26.9	19.1	18.8	44.1	38.0	38.3
Physical science								
Science	6.2	4.4	9.6	4.5	11.5	19.7	16.0	26.4
Math	12.2	9.3	17.6	11.0	12.7	31.0	29.9	35.1
Biological science								
Science	8.7	6.6	10.4	7.6	19.4	19.8	18.2	26.0
Math	23.3	19.2	27.0	21.5	22.4	48.8	38.1	42.7
Social science								
Science	9.1	7.0	10.6	9.0	17.1	21.5	19.2	16.2
Math	26.3	21.2	30.0	25.2	25.8	54.1	44.9	51.3
Engineering								
Science	8.5	7.4	13.4	6.4	14.6	20.5	23.0	18.0
Math	13.3	12.7	16.2	12.5	14.2	36.1	30.9	28.2
Non-S&E								
Science	10.1	8.6	11.2	10.4	18.3	22.2	24.6	25.5
Math	24.4	21.0	27.0	25.8	26.0	49.7	41.0	44.6

S&E = science and engineering

SOURCE: Higher Education Research Institute, University of California at Los Angeles, *Survey of the American Freshman: National Norms* (Los Angeles: 1992), unpublished tabulations.

See figure 2–11.

Science & Engineering Indicators – 1993

Appendix table 2–15.

Reasons given by high school seniors for not taking math and science classes: 1990 and 1993

Reason		All students	Sex		Plans after high school			
			Male	Female	Sci/math/eng major	Health major	Other college major	Noncollege-bound
		Math classes						
		Percent						
There were other courses I wanted to take	1990	37	33	40	36	41	47	34
	1993	37	34	40	36	32	35	33
I do not like math	1990	35	27	40	41	41	43	31
	1993	33	30	36	36	19	37	29
I did not think I would do well in more advanced math classes	1990	30	28	32	38	33	44	24
	1993	31	31	32	50	23	37	23
I was advised I did not need to take more math	1990	30	26	34	25	18	28	31
	1993	30	28	32	36	18	16	31
I will not need advanced math for what I plan to do in the future	1990	28	31	26	15	12	38	29
	1993	27	23	30	20	16	34	25
I did not want to work that hard during my senior year	1990	27	27	27	33	35	27	22
	1993	30	31	29	30	37	32	26
I have taken the highest level math course available here	1990	5	7	3	8	2	2	6
	1993	6	7	5	9	4	5	7
	1990 . . . . **N** =	677	293	384	61	49	197	405
	1993 . . . . **N** =	772	375	397	44	57	164	344
		Science classes						
I will not need advanced science for what I plan to do in the future	1990	40	42	37	35	12	52	39
	1993	34	36	33	25	4	47	31
There were other courses I wanted to take	1990	37	32	41	41	35	43	32
	1993	40	38	42	29	38	42	30
I was advised I did not need to take more science	1990	30	26	33	26	28	28	34
	1993	30	28	34	34	19	22	33
I do not like science	1990	29	22	35	24	19	36	29
	1993	29	26	32	25	10	35	26
I did not think I would do well in more advanced science classes	1990	24	24	24	24	16	29	22
	1993	25	22	29	23	18	28	21
I did not want to work that hard during my senior year	1990	23	21	25	26	27	28	21
	1993	27	26	28	28	18	26	28
I have taken the highest level science course available here	1990	8	9	7	6	20	7	6
	1993	9	10	8	9	8	5	10
	1990 . . . . **N** =	897	398	499	87	48	265	426
	1993 . . . . **N** =	965	487	478	61	53	248	392

SOURCE: J.D. Miller, Longitudinal Study of American Youth (DeKalb, IL: Social Science Research Institute, Northern Illinois University, 1993), special tabulations.

Science & Engineering Indicators – 1993

Appendix table 2–16.
Selected math and science courses taken by high school seniors: 1990 and 1993

Course		All students	Sex		Plans after high school			
			Male	Female	Sci/math/eng major	Health major	Other college major	Noncollege-bound
		Math classes						
		Percent						
Algebra	1990	89	88	89	98	99	97	77
	1993	91	91	92	98	98	98	79
Geometry	1990	71	70	71	93	95	89	48
	1993	74	73	75	94	92	89	46
Trigonometry	1990	28	31	27	67	52	38	6
	1993	36	36	37	74	54	42	8
Calculus	1990	8	10	6	26	16	11	*
	1993	11	13	9	33	16	8	*
	1990 **N** =	2,332	1,107	1,225	276	159	474	752
	1993 **N** =	2,046	1,071	975	229	199	464	579
		Science classes						
Low-level science	1990	75	74	76	62	60	73	84
	1993	73	74	72	52	62	73	90
Biology	1990	92	93	92	98	98	98	86
	1993	91	90	93	96	96	96	83
Chemistry	1990	53	54	53	84	84	73	27
	1993	60	59	62	85	83	75	29
Physics	1990	23	27	19	52	51	27	6
	1993	32	32	27	64	44	30	7
	1990 **N** =	2,296	1,096	1,201	276	159	486	748
	1993 **N** =	2,016	1,057	959	229	199	464	578

* = fewer than 1

SOURCE: J.D. Miller, Longitudinal Study of American Youth (DeKalb, IL: Social Science Research Institute, Northern Illinois University, 1993), special tabulations.

Science & Engineering Indicators – 1993

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Appendix table 2–17.

Earned associate degrees, by sex and field: 1975–91

Sex and field	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total, all degrees	362,969	395,393	409,942	416,947	407,471	405,710	420,910	440,000	461,888	457,851	459,087	451,258	440,816	441,093	440,375	459,048	486,297
Science and engineering	NA	NA	NA	NA	NA	NA	NA	NA	23,901	28,183	26,580	25,359	23,130	21,520	19,733	19,810	19,352
Natural sciences[1]	NA	NA	NA	NA	NA	NA	NA	NA	5,130	5,078	4,416	4,016	3,694	3,818	3,712	3,996	4,112
Math and computer sciences	NA	NA	NA	NA	NA	NA	NA	NA	10,695	13,696	13,679	11,567	9,953	9,575	8,846	8,600	8,640
Social & behavioral sciences 2/	NA	NA	NA	NA	NA	NA	NA	NA	4,803	4,852	4,562	4,487	4,894	4,231	4,440	4,809	4,087
Engineering	NA	NA	NA	NA	NA	NA	NA	NA	3,273	4,557	3,923	5,289	4,589	3,896	2,735	2,405	2,513
Engineering technology	30,906	36,263	38,588	41,708	41,716	43,696	52,478	58,574	51,332	50,718	53,693	49,904	49,813	49,640	48,342	46,931	45,104
Male, all degrees[1]	191,855	211,330	212,120	206,766	193,696	185,329	190,152	198,698	208,830	204,517	204,325	197,955	192,227	191,912	187,125	192,433	200,043
Science and engineering	NA	NA	NA	NA	NA	NA	NA	NA	13,184	15,736	14,746	14,446	13,152	12,266	10,607	10,568	10,360
Natural sciences[1]	NA	NA	NA	NA	NA	NA	NA	NA	3,003	2,974	2,511	2,216	2,113	2,151	1,965	2,195	2,278
Math and computer sciences	NA	NA	NA	NA	NA	NA	NA	NA	5,390	7,007	7,128	6,015	5,297	5,028	4,563	4,431	4,438
Social & behavioral sciences[2]	NA	NA	NA	NA	NA	NA	NA	NA	1,876	1,713	1,606	1,588	1,650	1,617	1,671	1,825	1,411
Engineering	NA	NA	NA	NA	NA	NA	NA	NA	2,915	4,042	3,501	4,627	4,092	3,470	2,408	2,117	2,233
Engineering technology	29,108	33,053	34,957	37,015	36,749	37,847	45,329	50,823	45,536	45,108	47,971	44,364	44,157	44,047	42,766	41,428	39,775
Female, all degrees	171,114	184,063	197,822	210,181	213,775	220,381	230,758	241,302	253,058	253,334	254,762	253,303	248,589	249,181	253,250	266,615	286,254
Science and engineering	NA	NA	NA	NA	NA	NA	NA	NA	10,717	12,447	11,834	10,913	9,978	9,254	9,126	9,242	8,992
Natural sciences[1]	NA	NA	NA	NA	NA	NA	NA	NA	2,127	2,104	1,905	1,800	1,581	1,667	1,747	1,801	1,834
Math and computer sciences	NA	NA	NA	NA	NA	NA	NA	NA	5,305	6,689	6,551	5,552	4,656	4,547	4,283	4,169	4,202
Social & behavioral sciences[2]	NA	NA	NA	NA	NA	NA	NA	NA	2,927	3,139	2,956	2,899	3,244	2,614	2,769	2,984	2,676
Engineering	NA	NA	NA	NA	NA	NA	NA	NA	358	515	422	662	497	426	327	288	280
Engineering technology	1,798	3,210	3,631	4,693	4,967	5,849	7,149	7,751	5,796	5,610	5,722	5,540	5,656	5,593	5,576	5,503	5,329

NA = not available

NOTE: Data on associate degrees are not available for broad science and engineering fields before 1983.

[1] The natural sciences include all physical, environmental, biological, and agricultural sciences.

[2] The social and behavioral sciences include psychology, sociology, and other social sciences.

SOURCES: National Center for Education Statistics, U.S. Department of Education, Earned Degrees and Completion Surveys; and Science Resources Studies Division, National Science Foundation, unpublished tabulations.

Science & Engineering Indicators – 1993

Appendix table 2–18.

Earned associate degrees, by race/ethnicity and field: 1977–91

Race/ethnicity and field	1977	1979	1981	1985	1987	1989	1990	1991
Total, all degrees	409,942	407,471	420,910	459,087	440,816	440,375	459,048	486,297
Science and engineering	NA	NA	NA	28,346	24,743	22,074	22,113	22,082
Natural sciences[1]	NA	NA	NA	4,691	3,950	3,952	4,286	4,430
Math and computer sciences	NA	NA	NA	13,679	9,953	8,846	8,600	8,640
Social & behavioral sciences[2]	NA	NA	NA	6,053	6,252	6,544	6,825	6,502
Engineering	NA	NA	NA	3,923	4,588	2,732	2,402	2,510
Engineering technology	38,244	40,891	51,661	51,579	47,434	46,180	44,739	42,595
White, all degrees	342,382	331,173	339,183	355,422	345,546	330,557	343,629	376,869
Science and engineering	NA	NA	NA	19,616	17,666	15,525	15,421	15,695
Natural sciences[1]	NA	NA	NA	3,548	3,078	3,231	3,458	3,574
Math and computer sciences	NA	NA	NA	10,255	7,360	6,044	5,704	6,054
Social & behavioral sciences[2]	NA	NA	NA	3,553	3,993	4,264	4,489	4,200
Engineering	NA	NA	NA	2,260	3,235	1,986	1,770	1,867
Engineering technology	33,109	33,662	40,804	40,934	37,383	33,584	31,699	33,792
Asian, all degrees	7,174	7,617	8,757	10,165	11,329	11,761	12,687	15,069
Science and engineering	NA	NA	NA	864	1,094	891	909	912
Natural sciences[1]	NA	NA	NA	86	112	120	179	220
Math and computer sciences	NA	NA	NA	511	464	401	411	388
Social & behavioral sciences[2]	NA	NA	NA	83	149	176	168	158
Engineering	NA	NA	NA	184	369	194	151	146
Engineering technology	781	1,132	1,641	1,570	1,989	1,663	1,499	1,496
Black, all degrees	33,176	34,985	35,330	35,861	33,858	32,185	32,882	37,854
Science and engineering	NA	NA	NA	2,027	2,127	1,817	1,924	2,038
Natural sciences[1]	NA	NA	NA	160	198	125	153	149
Math and computer sciences	NA	NA	NA	938	961	828	876	921
Social & behavioral sciences[2]	NA	NA	NA	781	719	744	807	842
Engineering	NA	NA	NA	148	249	120	88	126
Engineering technology	1,990	2,022	2,903	3,395	3,100	2,829	2,648	3,030
Hispanic, all degrees	19,808	20,710	22,088	22,783	22,804	23,475	24,569	29,019
Science and engineering	NA	NA	NA	1,776	2,031	1,744	1,473	1,740
Natural sciences[1]	NA	NA	NA	248	281	236	215	232
Math and computer sciences	NA	NA	NA	676	620	609	591	677
Social & behavioral sciences[2]	NA	NA	NA	726	761	723	569	678
Engineering	NA	NA	NA	126	369	176	98	153
Engineering technology	1,644	1,799	2,219	2,084	2,359	2,232	2,298	2,411
Native American, all degrees	2,499	2,336	2,584	2,953	3,049	3,102	3,290	3,772
Science and engineering	NA	NA	NA	193	245	227	251	326
Natural sciences[1]	NA	NA	NA	45	49	44	38	66
Math and computer sciences	NA	NA	NA	56	49	67	84	91
Social & behavioral sciences[2]	NA	NA	NA	81	120	104	117	148
Engineering	NA	NA	NA	11	27	12	12	21
Engineering technology	204	191	285	267	219	257	168	232

NA = not available

NOTES: Data on associate degrees are not available for broad science and engineering fields before 1983. Data by racial/ethinic group were collected on a biennial schedule until 1990. Data are not available by racial/ethnic group for foreign citizens on temporary visas. Data by racial/ethnic group are collected by broad fields of study only; therefore, these data cannot be adjusted to the exact field taxonomies used by the National Science Foundation.

[1] The natural sciences include all physical, environmental, biological, and agricultural sciences.

[2] The social and behavioral sciences include psychology, sociology, and other social sciences.

SOURCES: National Center for Education Statistics, U.S. Department of Education, Earned Degrees and Completion Surveys; and Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See text table 2–5.

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Appendix table 2–19.
Earned bachelors degrees, by sex and field: 1975–91
(page 1 of 2)

Sex and field	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total, all degrees	931,663	934,443	928,228	930,201	931,340	940,251	946,877	964,043	980,679	986,345	990,877	1,000,204	1,003,532	1,006,033	1,030,171	1,062,151	1,107,997
Science and engineering	313,555	309,491	303,798	303,555	303,162	304,695	306,792	315,023	317,875	324,483	332,422	335,460	331,526	322,482	322,821	329,094	337,675
Natural sciences	87,199	91,547	93,179	92,361	90,120	87,567	84,062	81,859	79,315	76,475	75,429	72,499	68,724	64,734	62,860	62,652	65,189
Physical	16,001	16,497	16,937	17,143	17,257	17,470	17,446	17,263	16,197	15,831	16,270	15,784	15,464	14,255	14,148	13,425	13,678
Environmental	4,877	5,046	5,653	6,003	6,082	6,155	6,694	7,061	7,298	7,925	7,576	6,076	4,689	3,554	3,181	2,776	2,728
Biological & agricultural	66,321	70,004	70,589	69,215	66,781	63,942	59,922	57,535	55,820	52,719	51,583	50,639	48,571	46,925	45,531	46,451	48,783
Math/computer sciences	23,385	21,749	20,729	19,925	20,670	22,686	26,406	32,139	37,239	45,777	54,388	58,583	56,442	50,877	46,277	42,369	40,194
Mathematics	18,346	16,085	14,303	12,701	11,901	11,473	11,173	11,708	12,557	13,342	15,267	16,388	16,515	15,981	15,314	14,674	14,784
Computer science	5,039	5,664	6,426	7,224	8,769	11,213	15,233	20,431	24,682	32,435	39,121	42,195	39,927	34,896	30,963	27,695	25,410
Social & behav. sci.	163,147	157,405	148,533	144,018	138,903	135,632	132,607	133,565	128,651	126,078	125,033	127,558	131,935	136,717	146,737	159,368	170,105
Psychology	51,436	50,363	47,794	45,057	43,012	42,513	41,364	41,539	40,825	40,375	40,237	40,937	43,195	45,378	48,954	54,018	58,893
Social science	111,711	107,042	100,739	98,961	95,891	93,119	91,243	92,026	87,826	85,703	84,796	86,621	88,740	91,339	97,783	105,350	111,212
Engineering	39,824	38,790	41,357	47,251	53,469	58,810	63,717	67,460	72,670	76,153	77,572	76,820	74,425	70,154	66,947	64,705	62,187
Engineering technology	8,589	9,180	9,864	10,314	10,906	12,180	13,567	14,778	18,663	20,225	20,533	20,928	20,577	20,447	20,098	19,150	18,294
Male, all degrees	508,424	508,549	499,121	491,066	481,394	477,750	474,336	477,543	483,395	486,750	486,660	490,143	485,003	481,236	487,566	495,867	508,952
Science and engineering	210,741	205,570	198,805	195,888	193,247	191,215	190,977	193,624	194,538	199,262	203,464	204,771	199,981	191,549	189,338	189,082	189,328
Natural sciences	63,977	65,572	65,378	63,014	60,047	56,909	53,430	51,213	48,379	46,482	45,447	43,405	40,589	36,930	36,009	35,157	36,206
Physical	12,990	13,280	13,560	13,453	13,358	13,285	13,137	12,737	11,586	11,175	11,434	11,088	10,792	9,673	9,777	9,106	9,253
Environmental	4,050	4,124	4,479	4,709	4,695	4,693	5,028	5,254	5,450	5,991	5,715	4,722	3,629	2,707	2,380	2,001	1,946
Biological & agricultural	46,937	48,168	47,339	44,852	41,994	38,931	35,265	33,222	31,343	29,316	28,298	27,595	26,168	24,550	23,852	24,050	25,007
Math/computer sciences	14,729	14,071	13,241	12,815	13,249	14,439	16,672	19,966	22,749	27,797	32,921	35,841	34,871	32,112	29,682	27,184	25,700
Mathematics	10,646	9,531	8,354	7,455	6,943	6,625	6,392	6,650	7,059	7,428	8,231	8,772	8,833	8,569	8,264	7,863	7,804
Computer science	4,083	4,540	4,887	5,360	6,306	7,814	10,280	13,316	15,690	20,369	24,690	27,069	26,038	23,543	21,418	19,321	17,896
Social & behav. sci.	93,056	88,454	80,873	76,290	71,363	67,009	64,221	63,260	60,392	59,559	58,770	59,843	61,500	63,132	66,888	72,009	74,900
Psychology	24,333	22,987	20,692	18,517	16,649	15,590	14,447	13,756	13,228	12,949	12,815	12,691	13,399	13,584	14,291	15,399	16,155
Social science	68,723	65,467	60,181	57,773	54,714	51,419	49,774	49,504	47,164	46,610	45,955	47,152	48,101	49,548	52,597	56,610	58,745
Engineering	38,979	37,473	39,313	43,769	48,588	52,858	56,654	59,185	63,018	65,424	66,326	65,682	63,021	59,375	56,759	54,732	52,522
Engineering technology	8,054	8,656	9,173	9,495	9,942	10,930	12,032	13,079	16,529	18,052	18,278	18,734	18,429	18,337	17,999	17,113	16,329

(continued)

Appendix table 2–19.

Earned bachelors degrees, by sex and field: 1975–91

(page 2 of 2)

Sex and field	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Female, all degrees	423,239	425,894	429,107	439,135	449,946	462,501	472,541	486,500	497,284	499,595	504,217	510,061	518,529	524,797	542,605	566,284	599,045
Science and engineering	102,814	103,921	104,993	107,667	109,915	113,480	115,815	121,399	123,337	125,221	128,958	130,689	131,545	130,933	133,483	140,012	148,347
Natural sciences	23,222	25,975	27,801	29,347	30,073	30,658	30,632	30,646	30,936	29,993	29,982	29,094	28,135	27,804	26,851	27,495	28,983
Physical	3,011	3,217	3,377	3,690	3,899	4,185	4,309	4,526	4,611	4,656	4,836	4,696	4,672	4,582	4,371	4,319	4,425
Environmental	827	922	1,174	1,294	1,387	1,462	1,666	1,807	1,848	1,934	1,861	1,354	1,060	847	801	775	782
Biological & agricultural	19,384	21,836	23,250	24,363	24,787	25,011	24,657	24,313	24,477	23,403	23,285	23,044	22,403	22,375	21,679	22,401	23,776
Math/computer sciences	8,656	7,678	7,488	7,110	7,421	8,247	9,734	12,173	14,490	17,980	21,467	22,742	21,571	18,765	16,595	15,185	14,494
Mathematics	7,700	6,554	5,949	5,246	4,958	4,848	4,781	5,058	5,498	5,914	7,036	7,616	7,682	7,412	7,050	6,811	6,980
Computer science	956	1,124	1,539	1,864	2,463	3,399	4,953	7,115	8,992	12,066	14,431	15,126	13,889	11,353	9,545	8,374	7,514
Social & behav. sci.	70,091	68,951	67,660	67,728	67,540	68,623	68,386	70,305	68,259	66,519	66,263	67,715	70,435	73,585	79,849	87,359	95,205
Psychology	27,103	27,376	27,102	26,540	26,363	26,923	26,917	27,783	27,597	27,426	27,422	28,246	29,796	31,794	34,663	38,619	42,738
Social science	42,988	41,575	40,558	41,188	41,177	41,700	41,469	42,522	40,662	39,093	38,841	39,469	40,639	41,791	45,186	48,740	52,467
Engineering	845	1,317	2,044	3,482	4,881	5,952	7,063	8,275	9,652	10,729	11,246	11,138	11,404	10,779	10,188	9,973	9,665
Engineering technology	535	524	691	819	964	1,250	1,533	1,699	2,134	2,173	2,255	2,194	2,148	2,110	2,099	2,037	1,965

SOURCES: National Center for Education Statistics, U.S. Department of Education, Earned Degrees and Completion Surveys; and Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See figure 2–12 and text table 2–6.

Science & Engineering Indicators – 1993

Appendix table 2–20.

Earned bachelors degrees, by race/ethnicity/citizenship and field: 1977–91

(page 1 of 2)

Race/ethnicity and field	1977	1979	1981	1985	1987	1989	1990	1991
Total, all degrees	928,228	931,340	946,877	990,877	1,003,532	1,030,171	1,062,151	1,107,997
Science and engineering	374,579	373,431	374,693	355,253	355,873	351,150	360,242	371,658
Natural sciences[1]	98,342	96,186	90,254	75,670	68,929	63,073	62,865	65,401
Math and computer sciences	20,729	20,670	26,406	54,388	56,442	46,277	42,369	40,194
Social & behavioral sciences[2]	205,831	193,775	182,638	147,624	156,079	174,853	190,305	203,877
Engineering	49,677	62,800	75,395	77,571	74,423	66,947	64,703	62,186
Engineering technology	NA	NA	NA	20,533	20,577	20,098	19,150	18,294
U.S. citizens and permanent residents								
White, all degrees	807,857	802,665	807,509	826,356	819,477	840,326	856,686	892,363
Science and engineering	323,845	318,819	313,486	290,388	281,588	277,106	280,889	289,253
Natural sciences[1]	88,308	85,403	78,778	63,592	55,898	50,580	49,527	51,113
Math and computer sciences	18,110	17,633	22,013	43,484	42,446	33,998	30,683	28,998
Social & behavioral sciences[2]	175,355	163,132	151,839	122,320	126,753	142,447	153,185	163,980
Engineering	42,072	52,651	60,856	60,992	56,491	50,081	47,494	45,162
Engineering technology	NA	NA	NA	16,673	16,541	16,156	15,251	14,279
Asian, all degrees	13,907	15,542	18,908	25,562	31,921	37,573	38,027	41,725
Science and engineering	6,558	7,591	9,572	13,454	17,114	19,383	19,698	20,860
Natural sciences[1]	1,935	2,227	2,406	2,880	3,641	3,973	4,308	4,670
Math and computer sciences	479	587	1,061	2,929	3,489	3,287	3,018	2,925
Social & behavioral sciences[2]	2,933	2,919	3,039	3,163	4,394	6,048	6,360	7,045
Engineering	1,211	1,858	3,066	4,482	5,590	6,075	6,012	6,220
Engineering technology	NA	NA	NA	542	807	839	755	768
Black, all degrees	58,700	60,301	60,729	57,563	55,103	56,837	59,301	65,009
Science and engineering	23,134	23,324	23,767	18,946	18,955	19,273	20,074	21,943
Natural sciences[1]	3,416	3,541	3,561	3,096	2,870	2,756	2,815	3,026
Math and computer sciences	1,073	1,159	1,371	2,913	3,654	3,249	2,967	2,808
Social & behavioral sciences[2]	17,260	16,849	16,386	10,898	10,116	11,201	12,220	13,880
Engineering	1,385	1,775	2,449	2,039	2,315	2,067	2,072	2,229
Engineering technology	NA	NA	NA	1,277	1,269	1,208	1,200	1,227
Hispanic, all degrees	27,043	29,719	33,167	36,391	38,196	41,361	43,864	49,027
Science and engineering	11,002	12,163	13,107	12,848	13,182	14,177	14,896	16,290
Natural sciences[1]	2,271	2,634	2,958	2,979	2,964	2,849	2,859	3,010
Math and computer sciences	435	495	688	1,380	1,696	1,568	1,498	1,695
Social & behavioral sciences[2]	7,006	7,479	7,641	6,302	5,968	7,199	8,028	9,019
Engineering	1,290	1,555	1,820	2,187	2,554	2,561	2,511	2,566
Engineering technology	NA	NA	NA	525	664	634	784	731
Native American, all degrees	3,328	3,410	3,593	4,246	3,866	3,967	4,212	4,486
Science and engineering	1,368	1,411	1,430	1,500	1,409	1,361	1,416	1,519
Natural sciences[1]	338	296	298	313	259	265	262	298
Math and computer sciences	41	52	39	198	164	143	129	123
Social & behavioral sciences[2]	854	899	898	780	776	776	879	940
Engineering	135	164	195	209	210	177	146	158
Engineering technology	NA	NA	NA	103	78	105	69	75

(continued)

Appendix table 2–20.
Earned bachelors degrees, by race/ethnicity/citizenship and field: 1977–91
(page 2 of 2)

Race/ethnicity and field	1977	1979	1981	1985	1987	1989	1990	1991
				Foreign citizens				
All degrees	15,744	17,853	22,631	29,258	28,592	26,457	26,553	29,657
Science and engineering	8,486	10,039	13,282	14,249	13,838	12,479	12,489	12,879
Natural sciences[1]	2,042	2,061	2,251	2,132	1,786	1,744	1,736	1,941
Math and computer sciences	583	741	1,233	2,879	3,233	2,678	2,590	2,615
Social & behavioral sciences[2]	2,287	2,473	2,835	3,048	2,930	2,985	3,246	3,741
Engineering	3,574	4,764	6,963	6,190	5,889	5,072	4,917	4,582
Engineering technology	NA	NA	NA	1,277	986	659	727	712

NA = not available

NOTES: Data by racial/ethnic group were collected on a biennial schedule until 1990. Data are not available by racial/ethnic group for foreign citizens on temporary visas. Data by racial/ethnic group are collected by broad fields of study only; therefore, these data cannot be adjusted to the exact field taxonomies used by the National Science Foundation.

[1] The natural sciences include all physical, environmental, biological, and agricultural sciences.

[2] The social and behavioral sciences include psychology, sociology, and other social sciences.

SOURCE: Science Resources Studies Division, National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1977–91*, Detailed Statistical Tables (Washington, DC: NSF, forthcoming).

Appendix table 2–21.

Proportion of total bachelors degrees obtained in science and engineering, by race/ethnicity/citizenship: 1977–91

	1977	1979	1981	1985	1987	1989	1990	1991
	Percent							
Whites								
Total science and engineering	40.1	39.7	38.8	35.1	34.4	33.0	32.8	32.4
Natural sciences	10.9	10.6	9.8	7.7	6.8	6.0	5.8	5.7
Math and computer sciences	2.2	2.2	2.7	5.3	5.2	4.0	3.6	3.2
Social and behavioral sciences	21.7	20.3	18.8	14.8	15.5	17.0	17.9	18.4
Engineering	5.2	6.6	7.5	7.4	6.9	6.0	5.5	5.1
Engineering technology	0.0	0.0	0.0	2.0	2.0	1.9	1.8	1.6
Asians								
Total science and engineering	47.2	48.8	50.6	52.6	53.6	51.6	51.8	50.0
Natural sciences	13.9	14.3	12.7	11.3	11.4	10.6	11.3	11.2
Math and computer sciences	3.4	3.8	5.6	11.5	10.9	8.7	7.9	7.0
Social and behavioral sciences	21.1	18.8	16.1	12.4	13.8	16.1	16.7	16.9
Engineering	8.7	12.0	16.2	17.5	17.5	16.2	15.8	14.9
Engineering technology	0.0	0.0	0.0	2.1	2.5	2.2	2.0	1.8
Blacks								
Total science and engineering	39.4	38.7	39.1	32.9	34.4	33.9	33.9	33.8
Natural sciences	5.8	5.9	5.9	5.4	5.2	4.8	4.7	4.7
Math and computer sciences	1.8	1.9	2.3	5.1	6.6	5.7	5.0	4.3
Social and behavioral sciences	29.4	27.9	27.0	18.9	18.4	19.7	20.6	21.4
Engineering	2.4	2.9	4.0	3.5	4.2	3.6	3.5	3.4
Engineering technology	0.0	0.0	0.0	2.2	2.3	2.1	2.0	1.9
Hispanics								
Total science and engineering	40.7	40.9	39.5	35.3	34.5	34.3	34.0	33.2
Natural sciences	8.4	8.9	8.9	8.2	7.8	6.9	6.5	6.1
Math and computer sciences	1.6	1.7	2.1	3.8	4.4	3.8	3.4	3.5
Social and behavioral sciences	25.9	25.2	23.0	17.3	15.6	17.4	18.3	18.4
Engineering	4.8	5.2	5.5	6.0	6.7	6.2	5.7	5.2
Engineering technology	0.0	0.0	0.0	1.4	1.7	1.5	1.8	1.5
Native Americans								
Total science and engineering	41.1	41.4	39.8	35.3	36.4	34.3	33.6	33.9
Natural sciences	10.2	8.7	8.3	7.4	6.7	6.7	6.2	6.6
Math and computer sciences	1.2	1.5	1.1	4.7	4.2	3.6	3.1	2.7
Social and behavioral sciences	25.7	26.4	25.0	18.4	20.1	19.6	20.9	21.0
Engineering	4.1	4.8	5.4	4.9	5.4	4.5	3.5	3.5
Engineering technology	0.0	0.0	0.0	2.4	2.0	2.6	1.6	1.7
Foreign citizens								
Total science and engineering	53.9	56.2	58.7	48.7	48.4	47.2	47.0	43.4
Natural sciences	13.0	11.5	9.9	7.3	6.2	6.6	6.5	6.5
Math and computer sciences	3.7	4.2	5.4	9.8	11.3	10.1	9.8	8.8
Social and behavioral sciences	14.5	13.9	12.5	10.4	10.2	11.3	12.2	12.6
Engineering	22.7	26.7	30.8	21.2	20.6	19.2	18.5	15.4
Engineering technology	0.0	0.0	0.0	4.4	3.4	2.5	2.7	2.4

SOURCE: Computed from appendix table 2–20.

Appendix table 2–22.
Participation rates in science and engineering bachelors degrees, by race/ethnicity/citizenship: 1977–91

	1977	1979	1981	1985	1987	1989	1990	1991
	Percent							
Whites								
Total, all fields	87.0	86.2	85.3	83.4	81.7	81.6	80.7	80.5
Science and engineering	86.5	85.4	83.7	81.7	79.1	78.9	78.0	77.8
Natural sciences	89.8	88.8	87.3	84.0	81.1	80.2	78.8	78.2
Math and computer sciences	87.4	85.3	83.4	80.0	75.2	73.5	72.4	72.1
Social & behavioral sciences	85.2	84.2	83.1	82.9	81.2	81.5	80.5	80.4
Engineering	84.7	83.8	80.7	78.6	75.9	74.8	73.4	72.6
Engineering technology	0.0	0.0	0.0	81.2	80.4	80.4	79.6	78.1
Asians								
Total, all fields	1.5	1.7	2.0	2.6	3.2	3.6	3.6	3.8
Science and engineering	1.8	2.0	2.6	3.8	4.8	5.5	5.5	5.6
Natural sciences	2.0	2.3	2.7	3.8	5.3	6.3	6.9	7.1
Math and computer sciences	2.3	2.8	4.0	5.4	6.2	7.1	7.1	7.3
Social & behavioral sciences	1.4	1.5	1.7	2.1	2.8	3.5	3.3	3.5
Engineering	2.4	3.0	4.1	5.8	7.5	9.1	9.3	10.0
Engineering technology	0.0	0.0	0.0	2.6	3.9	4.2	3.9	4.2
Blacks								
Total, all fields	6.3	6.5	6.4	5.8	5.5	5.5	5.6	5.9
Science and engineering	6.2	6.2	6.3	5.3	5.3	5.5	5.6	5.9
Natural sciences	3.5	3.7	3.9	4.1	4.2	4.4	4.5	4.6
Math and computer sciences	5.2	5.6	5.2	5.4	6.5	7.0	7.0	7.0
Social & behavioral sciences	8.4	8.7	9.0	7.4	6.5	6.4	6.4	6.8
Engineering	2.8	2.8	3.2	2.6	3.1	3.1	3.2	3.6
Engineering technology	0.0	0.0	0.0	6.2	6.2	6.0	6.3	6.7
Hispanics								
Total, all fields	2.9	3.2	3.5	3.7	3.8	4.0	4.1	4.4
Science and engineering	2.9	3.3	3.5	3.6	3.7	4.0	4.1	4.4
Natural sciences	2.3	2.7	3.3	3.9	4.3	4.5	4.5	4.6
Math and computer sciences	2.1	2.4	2.6	2.5	3.0	3.4	3.5	4.2
Social & behavioral sciences	3.4	3.9	4.2	4.3	3.8	4.1	4.2	4.4
Engineering	2.6	2.5	2.4	2.8	3.4	3.8	3.9	4.1
Engineering technology	0.0	0.0	0.0	2.6	3.2	3.2	4.1	4.0
Native Americans								
Total, all fields	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Science and engineering	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Natural sciences	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.5
Math and computer sciences	0.2	0.3	0.1	0.4	0.3	0.3	0.3	0.3
Social & behavioral sciences	0.4	0.5	0.5	0.5	0.5	0.4	0.5	0.5
Engineering	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3
Engineering technology	0.0	0.0	0.0	0.5	0.4	0.5	0.4	0.4
Foreign citizens								
Total, all fields	1.7	1.9	2.4	3.0	2.8	2.6	2.5	2.7
Science and engineering	2.3	2.7	3.5	4.0	3.9	3.6	3.5	3.5
Natural sciences	2.1	2.1	2.5	2.8	2.6	2.8	2.8	3.0
Math and computer sciences	2.8	3.6	4.7	5.3	5.7	5.8	6.1	6.5
Social & behavioral sciences	1.1	1.3	1.6	2.1	1.9	1.7	1.7	1.8
Engineering	7.2	7.6	9.2	8.0	7.9	7.6	7.6	7.4
Engineering technology	0.0	0.0	0.0	6.2	4.8	3.3	3.8	3.9

SOURCE: Computed from appendix table 2–20.

See figure 2–13.

Appendix table 2–23.

Graduate enrollment in science and engineering, by sex and field: 1977–91

Field	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total enrollment															
Science & engineering	312,011	308,627	320,016	326,683	333,005	339,765	348,315	350,755	359,554	369,047	373,762	376,821	384,691	395,298	415,240
Natural sciences	101,456	100,216	101,038	101,236	100,791	101,889	103,213	103,784	104,347	105,803	105,485	106,085	107,851	108,486	113,242
Math & computer sciences	25,177	25,002	26,741	28,928	32,343	36,990	40,996	43,269	47,424	49,364	50,661	51,657	51,936	54,155	54,720
Social & behavioral sciences	116,596	114,748	120,430	122,054	120,113	116,988	112,995	110,922	111,623	111,740	113,727	115,920	120,585	125,328	132,871
Engineering	68,782	68,661	71,807	74,465	79,758	83,898	91,111	92,780	96,160	102,140	103,889	103,159	104,319	107,329	114,407
Male enrollment															
Science & engineering	234,016	226,978	230,498	232,117	232,841	235,912	241,386	242,806	248,250	254,318	256,513	255,088	258,011	262,104	273,529
Natural sciences	76,220	73,854	73,045	72,187	70,827	70,434	70,851	70,993	70,902	71,461	70,962	70,195	70,606	70,292	72,263
Math & computer sciences	19,493	19,219	20,389	21,756	23,642	26,466	29,144	31,190	34,560	36,105	37,120	37,679	37,999	39,779	40,158
Social & behavioral sciences	73,226	69,896	71,142	70,049	66,368	63,907	60,071	58,184	57,788	57,077	57,504	57,262	58,762	59,408	62,557
Engineering	65,077	64,009	65,922	68,125	72,004	75,105	81,320	82,439	85,000	89,675	90,927	89,952	90,644	92,625	98,551
Female enrollment															
Science & engineering	77,995	81,649	89,518	94,566	100,164	103,853	106,929	107,949	111,304	114,729	117,249	121,733	126,680	133,194	141,711
Natural sciences	25,236	26,362	27,993	29,049	29,964	31,455	32,362	32,791	33,445	34,342	34,523	35,890	37,245	38,194	40,979
Math & computer sciences	5,684	5,783	6,352	7,172	8,701	10,524	11,852	12,079	12,864	13,259	13,541	13,978	13,937	14,376	14,562
Social & behavioral sciences	43,370	44,852	49,288	52,005	53,745	53,081	52,924	52,738	53,835	54,663	56,223	58,658	61,823	65,920	70,314
Engineering	3,705	4,652	5,885	6,340	7,754	8,793	9,791	10,341	11,160	12,465	12,962	13,207	13,675	14,704	15,856

SOURCE: Science Resources Studies Division, National Science Foundation, *Academic Science and Engineering, Graduate Enrollment and Support, Fall 1991*, Detailed Statistical Tables, NSF 93-309 (Washington, DC: NSF, 1993).

See figure 2–14.

Appendix table 2-24.
Graduate enrollment in science and engineering, by race/ethnicity/citizenship and field: 1983–91

Field	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total enrollment									
Total science and engineering	348,315	350,755	359,554	369,047	373,762	376,821	384,691	395,298	415,240
Natural sciences	103,213	103,784	104,347	105,803	105,485	106,085	107,851	108,486	113,242
Math and computer sciences	40,996	43,269	47,424	49,364	50,661	51,657	51,936	54,155	54,720
Social and behavioral sciences	112,995	110,922	111,623	111,740	113,727	115,920	120,585	125,328	132,871
Engineering	91,111	92,780	96,160	102,140	103,889	103,159	104,319	107,329	114,407
White enrollment									
Total science and engineering	225,313	223,420	224,177	227,998	229,011	229,950	231,001	237,686	245,172
Natural sciences	74,538	74,244	72,170	71,885	69,496	69,169	68,545	68,341	69,989
Math and computer sciences	23,762	23,942	25,367	26,015	26,799	27,653	26,634	27,864	27,119
Social and behavioral sciences	78,318	75,809	76,249	77,017	79,000	80,621	84,244	88,357	93,044
Engineering	48,695	49,425	50,391	53,081	53,716	52,507	51,578	53,124	55,020
Asian enrollment									
Total science and engineering	9,368	10,185	12,024	12,788	14,590	15,182	15,682	17,039	18,217
Natural sciences	2,389	2,535	2,727	2,771	3,061	3,450	3,581	3,874	4,305
Math and computer sciences	1,663	1,816	2,475	2,767	3,232	3,446	3,449	3,679	3,704
Social and behavioral sciences	1,911	2,019	2,010	2,127	2,441	2,370	2,659	2,789	3,005
Engineering	3,405	3,815	4,812	5,123	5,856	5,916	5,993	6,697	7,203
Black enrollment									
Total science and engineering	10,980	10,724	10,534	10,471	10,443	11,216	11,800	12,635	13,696
Natural sciences	1,983	2,004	1,993	1,839	1,821	1,980	2,097	2,137	2,311
Math and computer sciences	967	954	1,017	1,135	1,191	1,247	1,299	1,472	1,605
Social and behavioral sciences	6,637	6,306	6,115	6,024	6,009	6,469	6,765	7,228	7,746
Engineering	1,393	1,460	1,409	1,473	1,422	1,520	1,639	1,798	2,034
Hispanic enrollment									
Total science and engineering	8,901	8,692	8,623	8,659	8,812	9,093	9,464	10,132	11,168
Natural sciences	1,922	1,895	2,097	2,123	2,075	2,230	2,394	2,360	2,576
Math and computer sciences	612	584	743	715	810	845	851	920	978
Social and behavioral sciences	4,926	4,713	4,303	4,218	4,199	4,301	4,508	4,960	5,435
Engineering	1,441	1,500	1,480	1,603	1,728	1,717	1,711	1,892	2,179
Native American enrollment									
Total science and engineering	915	831	740	746	786	926	864	1,048	1,201
Natural sciences	224	207	169	198	183	220	180	251	329
Math and computer sciences	53	70	78	51	75	72	75	63	62
Social and behavioral sciences	457	362	371	366	404	490	485	583	621
Engineering	181	192	122	131	124	144	124	151	189
Foreign citizen enrollment									
Total science and engineering	70,381	72,297	76,853	84,035	88,806	93,849	98,272	101,835	108,408
Natural sciences	18,286	18,853	20,360	22,729	24,487	26,220	28,166	29,478	31,342
Math and computer sciences	10,502	11,552	12,803	13,816	14,857	15,422	16,337	17,356	18,021
Social and behavioral sciences	14,105	14,006	14,836	15,479	16,082	16,878	16,959	17,034	17,726
Engineering	27,488	27,886	28,854	32,011	33,380	35,329	36,810	37,967	41,319

NOTE: The natural sciences include all physical, environmental, biological, and agricultural sciences. The social and behavioral sciences include psychology, sociology, and other social sciences.

SOURCE: Science Resources Studies Division, National Science Foundation, *Academic Science and Engineering, Graduate Enrollment and Support, Fall 1991*, Detailed Statistical Tables, NSF 93-309 (Washington, DC: NSF, 1993).

See figures 2-15 and 2-16.

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Appendix table 2–25.

Earned masters degrees, by sex and field: 1975–91

(page 1 of 2)

Sex and field	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total, all degrees	293,651	313,001	318,241	312,816	302,075	299,095	296,798	296,580	290,931	285,462	287,213	289,829	290,532	300,091	311,050	324,947	338,498
Science and engineering	63,198	65,007	67,397	67,264	64,226	64,089	64,366	66,568	67,716	68,564	70,562	71,831	72,603	73,655	76,425	77,788	78,368
Natural sciences	14,831	14,684	15,360	15,546	15,443	14,832	14,349	14,702	14,380	14,231	13,972	13,910	13,400	13,184	13,218	12,928	12,682
Physical	4,298	3,880	3,641	3,713	3,650	3,408	3,366	3,491	3,285	3,544	3,605	3,649	3,574	3,708	3,876	3,805	3,777
Environmental	1,503	1,581	1,659	1,832	1,777	1,793	1,876	2,012	1,959	1,982	2,160	2,234	2,051	1,920	1,819	1,596	1,499
Biological & agricultural	9,030	9,223	10,060	10,001	10,016	9,631	9,107	9,199	9,136	8,705	8,207	8,027	7,775	7,556	7,523	7,527	7,406
Math/computer sciences	6,637	6,466	6,496	6,421	6,101	6,515	6,787	7,666	8,160	8,939	9,989	11,241	11,808	12,600	12,829	13,327	12,956
Mathematics	4,338	3,863	3,698	3,383	3,046	2,868	2,569	2,731	2,839	2,749	2,888	3,171	3,327	3,434	3,430	3,684	3,632
Computer science	2,299	2,603	2,798	3,038	3,055	3,647	4,218	4,935	5,321	6,190	7,101	8,070	8,481	9,166	9,399	9,643	9,324
Social & behav. sci.	26,563	27,812	29,529	29,217	27,403	26,799	26,779	26,643	26,290	25,249	25,629	25,584	25,325	25,145	26,635	27,538	28,717
Psychology	7,104	7,859	8,320	8,194	8,031	7,861	8,039	7,849	8,439	8,073	8,481	8,363	8,165	7,925	8,652	9,308	9,802
Social science	19,459	19,953	21,209	21,023	19,372	18,938	18,740	18,794	17,851	17,176	17,148	17,221	17,160	17,220	17,983	18,230	18,915
Engineering	15,167	16,045	16,012	16,080	15,279	15,943	16,451	17,557	18,886	20,145	20,972	21,096	22,070	22,726	23,743	23,995	24,013
Engineering technology	371	493	505	579	496	510	532	636	622	694	816	925	883	980	1,135	1,194	1,188
Male, all degrees	162,115	167,745	168,210	161,708	153,772	151,159	147,431	145,941	145,114	143,998	143,716	143,932	141,655	145,403	149,399	154,025	156,895
Science and engineering	49,410	49,992	50,899	50,034	46,614	46,004	45,505	46,557	46,718	47,033	48,232	48,611	48,759	49,820	50,845	51,230	50,441
Natural sciences	11,709	11,388	11,633	11,583	11,223	10,729	10,222	10,200	9,814	9,513	9,290	9,133	8,652	8,562	8,383	8,052	7,794
Physical	3,645	3,275	2,981	3,060	2,971	2,770	2,691	2,744	2,600	2,698	2,775	2,736	2,684	2,817	2,836	2,754	2,703
Environmental	1,309	1,361	1,433	1,542	1,467	1,457	1,470	1,560	1,515	1,517	1,639	1,717	1,531	1,433	1,337	1,218	1,116
Biological & agricultural	6,755	6,752	7,219	6,981	6,785	6,502	6,061	5,896	5,699	5,298	4,876	4,680	4,437	4,312	4,210	4,080	3,975
Math/computer sciences	4,871	4,776	4,730	4,704	4,469	4,715	4,939	5,446	5,672	6,174	6,941	7,713	8,011	8,759	8,833	9,176	8,709
Mathematics	2,910	2,550	2,398	2,233	1,989	1,832	1,692	1,821	1,859	1,795	1,877	2,055	2,026	2,057	2,060	2,208	2,146
Computer science	1,961	2,226	2,332	2,471	2,480	2,883	3,247	3,625	3,813	4,379	5,064	5,658	5,985	6,702	6,773	6,968	6,563
Social & behav. sci.	18,035	18,351	19,222	18,510	16,580	15,740	15,222	14,929	14,101	13,301	13,273	13,069	12,796	12,581	12,968	13,276	13,282
Psychology	4,059	4,188	4,316	3,931	3,688	3,397	3,371	3,228	3,254	2,980	3,064	2,937	2,838	2,599	2,814	3,025	2,994
Social science	13,976	14,163	14,906	14,579	12,892	12,343	11,851	11,701	10,847	10,321	10,209	10,132	9,958	9,982	10,154	10,251	10,288
Engineering	14,795	15,477	15,314	15,237	14,342	14,820	15,122	15,982	17,131	18,045	18,728	18,696	19,300	19,918	20,661	20,726	20,656
Engineering technology	281	424	389	480	371	424	380	486	519	580	674	710	678	738	892	888	888

(continued)

Appendix table 2–25.
Earned masters degrees, by sex and field: 1975–91
(page 2 of 2)

Sex and field	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Female, all degrees	131,536	145,256	150,031	151,108	148,303	147,936	149,367	150,639	145,817	141,464	143,497	145,897	148,877	154,688	161,651	170,922	181,603
Science and engineering	13,788	15,015	16,498	17,230	17,612	18,085	18,861	20,011	20,998	21,531	22,330	23,220	23,844	23,835	25,580	26,558	27,927
Natural sciences	3,122	3,296	3,727	3,963	4,220	4,103	4,127	4,502	4,566	4,718	4,682	4,777	4,748	4,622	4,835	4,876	4,888
Physical	653	605	660	653	679	638	675	747	685	846	830	913	890	891	1,040	1,051	1,074
Environmental	194	220	226	290	310	336	406	452	444	465	521	517	520	487	482	378	383
Biological & agricultural	2,275	2,471	2,841	3,020	3,231	3,129	3,046	3,303	3,437	3,407	3,331	3,347	3,338	3,244	3,313	3,447	3,431
Math/computer sciences	1,766	1,690	1,766	1,717	1,632	1,800	1,848	2,220	2,488	2,765	3,048	3,528	3,797	3,841	3,996	4,151	4,247
Mathematics	1,428	1,313	1,300	1,150	1,057	1,036	877	910	980	954	1,011	1,116	1,301	1,377	1,370	1,476	1,486
Computer science	338	377	466	567	575	764	971	1,310	1,508	1,811	2,037	2,412	2,496	2,464	2,626	2,675	2,761
Social & behav. sci.	8,528	9,461	10,307	10,707	10,823	11,059	11,557	11,714	12,189	11,948	12,356	12,515	12,529	12,564	13,667	14,262	15,435
Psychology	3,045	3,671	4,004	4,263	4,343	4,464	4,668	4,621	5,185	5,093	5,417	5,426	5,327	5,326	5,838	6,283	6,808
Social science	5,483	5,790	6,303	6,444	6,480	6,595	6,889	7,093	7,004	6,855	6,939	7,089	7,202	7,238	7,829	7,979	8,627
Engineering	372	568	698	843	937	1,123	1,329	1,575	1,755	2,100	2,244	2,400	2,770	2,808	3,082	3,269	3,357
Engineering technology	90	69	116	99	125	86	152	150	103	114	142	215	205	242	243	306	300

SOURCES: National Center for Education Statistics, U.S. Department of Education, Earned Degrees and Completion Surveys; and Science Resources Studies Division, National Science Foundation, unpublished tabulations.

Science & Engineering Indicators – 1993

Appendix table 2–26.
Earned masters degrees, by race/ethnicity/citizenship and field: 1977–91
(page 1 of 2)

Race/ethnicity and field	1977	1979	1981	1985	1987	1989	1990	1991
Total, all degrees	318,241	302,075	296,798	287,213	290,532	311,050	324,947	338,498
Science and engineering	83,475	79,785	79,869	80,630	83,515	87,783	89,826	91,126
Natural sciences[1]	16,234	16,350	15,332	14,045	13,461	13,260	12,966	12,713
Math and computer sciences	6,496	6,101	6,787	9,989	11,808	12,829	13,327	12,956
Social & behavioral sciences[2]	44,494	41,824	41,034	35,661	36,189	37,959	39,548	41,450
Engineering	16,251	15,510	16,716	20,935	22,057	23,735	23,985	24,007
Engineering technology	NA	NA	NA	816	883	1,135	1,194	1,188
U.S. citizens and permanent residents								
White, all degrees	266,109	249,401	241,255	223,649	216,807	230,322	236,874	247,524
Science and engineering	66,661	62,158	60,407	56,101	55,790	56,864	57,606	58,435
Natural sciences[1]	13,405	13,282	12,411	10,559	9,623	9,262	8,722	8,300
Math and computer sciences	5,256	4,625	4,708	6,176	6,729	6,818	7,020	6,705
Social & behavioral sciences[2]	36,556	34,169	33,141	27,180	26,601	27,952	29,005	30,795
Engineering	11,444	10,082	10,147	12,186	12,837	12,832	12,859	12,635
Engineering technology	NA	NA	NA	526	581	802	823	830
Asian, all degrees	5,145	5,519	6,304	7,805	8,129	10,174	9,994	11,070
Science and engineering	2,021	2,232	2,481	3,543	3,745	4,482	4,393	4,676
Natural sciences[1]	388	469	365	450	464	545	504	532
Math and computer sciences	198	253	376	779	962	1,072	1,125	1,203
Social & behavioral sciences[2]	698	660	661	763	669	873	901	933
Engineering	737	850	1,079	1,551	1,650	1,992	1,863	2,008
Engineering technology	NA	NA	NA	25	46	40	79	60
Black, all degrees	21,041	19,422	17,152	13,960	13,173	13,455	14,473	15,857
Science and engineering	4,197	4,042	3,695	3,152	3,223	3,151	3,559	3,825
Natural sciences[1]	351	382	351	290	301	238	225	261
Math and computer sciences	200	136	137	233	280	257	302	383
Social & behavioral sciences[2]	3,406	3,278	2,947	2,299	2,239	2,301	2,645	2,783
Engineering	240	246	260	330	403	355	387	398
Engineering technology	NA	NA	NA	37	42	55	44	47
Hispanic, all degrees	7,071	6,470	7,439	7,730	7,781	8,133	8,495	9,684
Science and engineering	2,078	1,702	2,052	2,231	2,291	2,339	2,321	2,575
Natural sciences[1]	245	227	251	332	310	266	262	281
Math and computer sciences	91	61	102	149	183	178	169	213
Social & behavioral sciences[2]	1,491	1,199	1,414	1,404	1,286	1,427	1,444	1,613
Engineering	251	215	285	346	512	468	446	468
Engineering technology	NA	NA	NA	6	17	10	9	19
Native American, all degrees	968	999	1,034	1,257	1,049	1,082	1,050	1,125
Science and engineering	225	246	257	313	270	302	258	294
Natural sciences[1]	48	50	33	45	23	41	31	34
Math and computer sciences	15	24	19	48	25	45	13	23
Social & behavioral sciences[2]	139	148	174	173	184	183	179	197
Engineering	23	24	31	47	38	33	35	40
Engineering technology	NA	NA	NA	2	26	2	5	3

(continued)

Appendix table 2–26.

Earned masters degrees, by race/ethnicity/citizenship and field: 1977–91

(page 2 of 2)

	1977	1979	1981	1985	1987	1989	1990	1991
				Foreign citizens				
All degrees	17,345	19,427	22,058	26,952	28,264	32,123	34,602	37,611
Science and engineering	8,282	9,111	10,468	13,132	13,764	15,949	17,077	17,841
Natural sciences[1]	1,797	1,895	1,864	2,178	2,132	2,504	2,732	2,856
Math and computer sciences	736	937	1,368	2,394	2,903	3,418	3,598	3,878
Social & behavioral sciences[2]	2,204	2,319	2,673	2,866	2,948	3,280	3,508	3,587
Engineering	3,545	3,960	4,563	5,694	5,781	6,747	7,239	7,520
Engineering technology	NA	NA	NA	124	127	131	162	172

NA = not available

NOTES: Data by racial/ethnic group were collected on a biennial schedule until 1990. Data are not available by racial/ethnic group for foreign citizens on temporary visas. Data by racial/ethnic group are collected by broad fields of study only; therefore, these data cannot be adjusted to the exact field taxonomies used by the National Science Foundation.

[1] The natural sciences include all physical, environmental, biological, and agricultural sciences.

[2] The social and behavioral sciences include psychology, sociology, and other social sciences.

SOURCE: Science Resources Studies Division, National Science Foundation, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1977–91,* Detailed Statistical Tables (Washington,DC: NSF, forthcoming).

See text table 2–7.

Science & Engineering Indicators – 1993

Appendix table 2–27.

Earned doctoral degrees, by sex and field: 1975–91

(page 1 of 2)

Sex and field	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total, all degrees	32,952	32,946	31,716	30,875	31,239	31,020	31,357	31,111	31,282	31,337	31,297	31,895	32,363	33,490	34,318	36,057	37,451
Science and engineering	18,924	18,608	18,077	17,614	17,753	17,668	18,143	18,190	18,506	18,641	18,824	19,339	19,784	20,832	21,625	22,763	23,854
Natural sciences	8,103	7,863	7,676	7,601	7,817	7,864	7,996	8,195	8,195	8,336	8,437	8,484	8,655	9,173	9,185	9,766	10,152
Physical science	3,076	2,861	2,721	2,611	2,674	2,521	2,627	2,694	2,815	2,851	2,934	3,120	3,238	3,351	3,261	3,523	3,623
Environmental	625	641	689	621	642	628	583	657	624	608	599	559	602	695	723	738	816
Biological & agricultural	4,402	4,361	4,266	4,369	4,501	4,715	4,786	4,844	4,756	4,877	4,904	4,805	4,815	5,127	5,201	5,505	5,713
Math/computer sciences	1,360	1,247	1,149	1,034	979	962	960	940	987	993	998	1,128	1,190	1,264	1,471	1,597	1,837
Mathematics	1,147	1,003	933	838	769	744	728	720	701	698	688	729	740	749	859	892	1,040
Computer science	213	244	216	196	210	218	232	220	286	295	310	399	450	515	612	705	797
Social & behav. sci.	6,450	6,660	6,604	6,554	6,463	6,363	6,659	6,409	6,543	6,399	6,223	6,351	6,227	6,207	6,425	6,507	6,653
Psychology	2,751	2,883	2,990	3,055	3,091	3,098	3,358	3,159	3,347	3,257	3,117	3,124	3,169	3,064	3,203	3,269	3,240
Social science	3,699	3,777	3,614	3,499	3,372	3,265	3,301	3,250	3,196	3,142	3,106	3,227	3,058	3,143	3,222	3,238	3,413
Engineering	3,011	2,838	2,648	2,425	2,494	2,479	2,528	2,646	2,781	2,913	3,166	3,376	3,712	4,188	4,544	4,893	5,212
Male, all degrees	25,751	25,262	23,858	22,553	22,302	21,612	21,465	21,018	20,749	20,638	20,553	20,591	20,938	21,678	21,811	22,954	23,224
Science and engineering	16,005	15,525	14,878	14,200	14,050	13,753	14,000	13,883	13,856	13,902	13,984	14,225	14,531	15,226	15,581	16,447	16,895
Natural sciences	6,960	6,704	6,530	6,335	6,436	6,328	6,410	6,443	6,361	6,483	6,453	6,427	6,484	6,780	6,649	7,102	7,340
Physical science	2,812	2,617	2,477	2,364	2,382	2,199	2,318	2,337	2,442	2,452	2,467	2,610	2,710	2,784	2,642	2,862	2,957
Environmental	595	579	630	560	584	564	527	554	529	502	491	464	490	560	575	597	638
Biological & agricultural	3,553	3,508	3,423	3,411	3,470	3,565	3,565	3,552	3,390	3,529	3,495	3,353	3,284	3,436	3,432	3,643	3,745
Math/computer sciences	1,237	1,111	1,008	899	833	846	822	824	838	841	859	959	1,000	1,087	1,208	1,329	1,527
Mathematics	1,038	890	811	718	650	649	616	624	588	583	582	608	615	628	704	734	846
Computer science	199	221	197	181	183	197	206	200	250	258	277	351	385	459	504	595	681
Social & behav. sci.	4,849	4,927	4,766	4,594	4,349	4,190	4,339	4,094	4,000	3,816	3,704	3,688	3,577	3,457	3,555	3,538	3,438
Psychology	1,878	1,937	1,902	1,928	1,831	1,787	1,885	1,721	1,750	1,626	1,576	1,526	1,474	1,388	1,406	1,362	1,256
Social science	2,971	2,990	2,864	2,666	2,518	2,403	2,454	2,373	2,250	2,190	2,128	2,162	2,103	2,069	2,149	2,176	2,182
Engineering	2,959	2,783	2,574	2,372	2,432	2,389	2,429	2,522	2,657	2,762	2,968	3,151	3,470	3,902	4,169	4,478	4,590

(continued)

Appendix table 2–27.

Earned doctoral degrees, by sex and field: 1975–91

(page 2 of 2)

Sex and field	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Female, all degrees	7,201	7,684	7,858	8,322	8,937	9,408	9,892	10,093	10,533	10,699	10,744	11,304	11,425	11,812	12,507	13,102	13,765
Science and engineering	2,919	3,083	3,199	3,414	3,703	3,915	4,143	4,307	4,650	4,739	4,840	5,114	5,253	5,606	6,044	6,316	6,789
Natural sciences	1,143	1,159	1,146	1,266	1,381	1,536	1,586	1,752	1,834	1,853	1,984	2,057	2,171	2,393	2,536	2,664	2,812
Physical science	264	244	244	247	292	322	309	357	373	399	467	510	528	567	619	661	666
Environmental	30	62	59	61	58	64	56	103	95	106	108	95	112	135	148	141	178
Biological & agricultural	849	853	843	958	1,031	1,150	1,221	1,292	1,366	1,348	1,409	1,452	1,531	1,691	1,769	1,862	1,968
Math/computer sciences	123	136	141	135	146	116	138	116	149	152	139	169	190	177	263	268	310
Mathematics	109	113	122	120	119	95	112	96	113	115	106	121	125	121	155	158	194
Computer science	14	23	19	15	27	21	26	20	36	37	33	48	65	56	108	110	116
Social & behav. sci.	1,601	1,733	1,838	1,960	2,114	2,173	2,320	2,315	2,543	2,583	2,519	2,663	2,650	2,750	2,870	2,969	3,215
Psychology	873	946	1,088	1,127	1,260	1,311	1,473	1,438	1,597	1,631	1,541	1,598	1,695	1,676	1,797	1,907	1,984
Social science	728	787	750	833	854	862	847	877	946	952	978	1,065	955	1,074	1,073	1,062	1,231
Engineering	52	55	74	53	62	90	99	124	124	151	198	225	242	286	375	415	452

SOURCE: Science Resources Studies Division, National Science Foundation, *Science and Engineering Doctorates: 1960–91*, Detailed Statistical Tables, NSF 93-301 (Washington, DC: NSF, 1993).

Science & Engineering Indicators – 1993

Appendix table 2–28.

Earned doctoral degrees by race/ethnicity, field, and citizenship: 1977–91

(page 1 of 2)

Race/ethnicity and field	1977	1979	1981	1985	1987	1989	1990	1991
Total[1]								
Total, all degrees	31,716	31,239	31,357	31,297	32,363	34,318	36,057	37,451
Science and engineering	8,016	17,872	18,258	18,935	19,890	21,727	22,857	23,979
Natural sciences[2]	6,622	7,817	7,996	8,437	8,655	9,185	9,766	10,152
Math and computer sciences	1,618	979	960	998	1,190	1,471	1,597	1,837
Social and behavioral sciences[3]	7,135	6,463	6,659	6,223	6,227	6,425	6,507	6,653
Engineering	2,633	2,494	2,528	3,166	3,712	4,544	4,893	5,212
Total U.S. citizens and permanent residents								
Total, all degrees	27,487	26,784	26,342	24,694	24,561	25,026	26,581	26,535
Science and engineering	14,889	14,711	14,655	14,065	14,055	14,592	15,346	15,360
Natural sciences[2]	6,427	6,604	6,641	6,634	6,450	6,628	6,942	6,898
Math and computer sciences	769	778	713	631	671	824	825	935
Social and behavioral sciences[3]	5886	5712	5830	5206	5021	4911	5239	5169
Engineering	1,799	1,617	1,471	1,594	1,913	2,229	2,340	2,358
White, all degrees	23,654	22,396	22,470	21,297	21,116	21,569	22,862	22,604
Science and engineering	12,875	12,314	12,573	12,166	12,051	12,501	13,156	12,983
Natural sciences[2]	5,598	5,620	5,771	5,902	5,662	5,800	6,078	5,993
Math and computer sciences	671	658	610	527	548	688	711	758
Social and behavioral sciences[3]	5,177	4,879	5,099	4,549	4,383	4,287	4,531	4,444
Engineering	1,429	1,157	1,093	1,188	1,458	1,726	1,836	1,788
Asian, all degrees	910	1,102	1,073	1,069	1,167	1,261	1,302	1,491
Science and engineering	745	884	827	809	924	981	1,006	1,157
Natural sciences[2]	342	377	344	346	369	400	411	462
Math and computer sciences	42	55	56	50	67	76	75	122
Social and behavioral sciences[3]	112	146	142	132	161	145	163	172
Engineering	249	306	285	281	327	360	357	401
Black, all degrees	1,194	1,114	1,110	1,043	907	962	1,046	1,082
Science and engineering	344	347	346	374	319	366	371	431
Natural sciences[2]	85	84	89	100	95	105	98	108
Math and computer sciences	10	12	11	10	13	9	5	19
Social and behavioral sciences[3]	234	231	227	230	186	219	228	249
Engineering	15	20	19	34	25	33	40	55
Hispanic, all degrees	474	539	526	634	709	694	835	843
Science and engineering	194	231	239	296	357	384	465	478
Natural sciences[2]	74	83	92	107	138	158	196	187
Math and computer sciences	10	12	5	18	15	15	15	20
Social and behavioral sciences[3]	88	112	126	149	170	163	200	212
Engineering	22	24	16	22	34	48	54	59
Native American, all degrees	66	81	85	96	115	94	96	130
Science and engineering	31	29	28	41	53	53	42	56
Natural sciences[2]	14	6	8	21	20	25	12	27
Math and computer sciences	1	1	1	0	3	2	1	1
Social and behavioral sciences[3]	15	19	15	19	23	19	25	22
Engineering	1	3	4	1	7	7	4	6

(continued)

Appendix table 2–28.

Earned doctoral degrees by race/ethnicity, field, and citizenship: 1977–91

(page 2 of 2)

Race/ethnicity and field	1977	1979	1981	1985	1987	1989	1990	1991
Foreign citizen								
Total, all degrees	3,448	3,587	3,940	5,228	5,610	6,647	8,074	8,852
Science and engineering	2,675	2,689	2,983	4,048	4,468	5,392	6,555	7,281
Natural sciences[2]	1,079	1,046	1,140	1,518	1,704	1,975	2,531	2,843
Math and computer sciences	170	181	226	327	445	524	695	818
Social and behavioral sciences[3]	651	645	675	784	787	952	1,056	1,147
Engineering	775	817	942	1,419	1,532	1,941	2,273	2,473
Unknown citizenship								
Total, all degrees	781	868	1,075	1,375	2,192	2,645	1,402	2,064
Science and engineering	452	472	620	822	1,367	1,743	956	1,338
Natural sciences[2]	170	167	215	285	501	582	293	411
Math and computer sciences	25	20	21	40	74	123	77	84
Social and behavioral sciences[3]	183	225	269	344	525	664	306	462
Engineering	74	60	115	153	267	374	280	381

NOTES: Data by racial/ethnic group were collected on a biennial schedule until 1990. Data are not available by racial/ethnic group for foreign citizens on temporary visas. Data by racial/ethnic group are collected by broad fields of study only; therefore, these data cannot be adjusted to the exact field taxonomies used by the National Science Foundation.

[1] Includes all doctorates awarded to U.S. citizens and permanent residents, temporary residents, and persons whose citizenship is unknown.

[2] The natural sciences include all physical, environmental, biological, and agricultural sciences.

[3] The social and behavioral sciences include psychology, sociology, and other social sciences.

SOURCE: Science Resources Studies Division, National Science Foundation, *Science and Engineering Doctorates: 1960–91*, Detailed Statistical Tables, NSF 93-301 (Washington, DC: NSF, 1993).

See figure 2–16.

Science & Engineering Indicators – 1993

Appendix table 2–29.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1980, 1990, and 1991
(page 1 of 4)

Region/country	1980					1990					1991				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
All fields															
Asia	1,509	787	52.2%	650	43.1%	5,279	2,390	45.3%	1,732	32.8%	6,138	3,625	59.1%	2,289	37.3%
China[1]	303	168	55.4%	135	44.6%	1,090	651	59.7%	456	41.8%	1,710	1,408	82.3%	858	50.2%
Taiwan	455	280	61.5%	236	51.9%	1,145	476	41.6%	314	27.4%	1,280	634	49.5%	365	28.5%
Japan	92	30	32.6%	24	26.1%	186	73	39.2%	55	29.6%	157	65	41.4%	44	28.0%
South Korea	158	68	43.0%	56	35.4%	1,257	367	29.2%	272	21.6%	1,333	452	33.9%	284	21.3%
India	420	292	69.5%	236	56.2%	877	585	66.7%	469	53.5%	883	686	77.7%	515	58.3%
Other Asia	384	117	30.5%	98	25.5%	724	238	32.9%	166	22.9%	775	380	49.0%	223	28.8%
Science and engineering															
Asia	1,237	729	58.9%	590	47.7%	4,367	2,108	48.3%	1,505	34.5%	5,156	3,208	62.2%	2,015	39.1%
China[1]	290	162	55.9%	135	46.6%	1,017	616	60.6%	434	42.7%	1,596	1,323	82.9%	807	50.6%
Taiwan	423	266	62.9%	224	53.0%	1,009	450	44.6%	299	29.6%	1,082	577	53.3%	344	31.8%
Japan	69	25	36.2%	19	27.5%	147	60	40.8%	48	32.7%	120	50	41.7%	35	29.2%
South Korea	131	64	48.9%	54	41.2%	970	307	31.6%	226	23.3%	1,067	389	36.5%	242	22.7%
India	369	265	71.8%	212	57.5%	705	466	66.1%	370	52.5%	719	552	76.8%	406	56.5%
Other Asia	275	109	39.6%	92	33.5%	560	209	37.3%	143	25.5%	579	317	54.7%	181	31.3%
Natural science															
Asia	590	341	57.8%	274	46.4%	2,236	1,183	52.9%	898	40.2%	2,593	1,803	69.5%	1,209	46.6%
China[1]	196	118	60.2%	99	50.5%	675	423	62.7%	323	47.9%	1,105	924	83.6%	611	55.3%
Taiwan	227	141	62.1%	118	52.0%	457	221	48.4%	153	33.5%	408	246	60.3%	151	37.0%
Japan	20	12	60.0%	8	40.0%	58	31	53.4%	25	43.1%	45	25	55.6%	17	37.8%
South Korea	46	26	56.5%	20	43.5%	407	168	41.3%	134	32.9%	415	186	44.8%	131	31.6%
India	155	105	67.7%	80	51.6%	317	220	69.4%	180	56.8%	295	225	76.3%	174	59.0%
Other Asia	142	57	40.1%	48	33.8%	322	120	37.3%	83	25.8%	325	197	60.6%	125	38.5%
Social science															
Asia	153	56	36.6%	34	22.2%	534	170	31.8%	105	19.7%	651	258	39.6%	160	24.6%
China[1]	10	5	50.0%	4	40.0%	53	31	58.5%	21	39.6%	76	58	76.3%	29	38.2%
Taiwan	24	11	45.8%	10	41.7%	78	22	28.2%	12	15.4%	101	38	37.6%	31	30.7%
Japan	22	6	27.3%	6	27.3%	72	24	33.3%	19	26.4%	47	18	38.3%	12	25.5%
South Korea	44	13	29.5%	10	22.7%	204	36	17.6%	26	12.7%	240	55	22.9%	33	13.8%
India	30	17	56.7%	11	36.7%	75	36	48.0%	29	38.7%	86	56	65.1%	42	48.8%
Other Asia	53	9	17.0%	2	3.8%	52	21	40.4%	2	3.8%	60	33	55.0%	13	21.7%

(continued)

Appendix table 2-29.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1980, 1990, and 1991
(page 2 of 4)

Region/country	1980			1990			1991		
	Total Ph.D. recipients	Plan to stay in U.S.	Firm plans to stay in U.S.	Total Ph.D. recipients	Plan to stay in U.S.	Firm plans to stay in U.S.	Total Ph.D. recipients	Plan to stay in U.S.	Firm plans to stay in U.S.
Engineering									
Asia	494	332 67.2%	282 57.1%	1,597	755 47.3%	502 31.4%	1,912	1,147 60.0%	646 33.8%
China[1]	84	390 46.4%	32 38.1%	289	162 56.1%	90 31.1%	415	341 82.2%	167 40.2%
Taiwan	172	114 66.3%	96 55.8%	474	207 43.7%	134 28.3%	573	293 51.1%	162 28.3%
Japan	27	7 25.9%	5 18.5%	17	5 29.4%	4 23.5%	28	7 25.0%	6 21.4%
South Korea	41	25 61.0%	24 58.5%	359	103 28.7%	66 18.4%	412	148 35.9%	78 18.9%
India	184	143 77.7%	121 65.8%	313	210 67.1%	161 51.4%	338	271 80.2%	190 56.2%
Other Asia	70	43 61.4%	36 51.4%	145	68 46.9%	47 32.4%	146	87 59.6%	43 29.5%
All fields									
Europe	501	232 46.3%	213 42.5%	1,092	540 49.5%	411 37.6%	1,273	735 57.7%	532 41.8%
Greece	72	67 93.1%	28 38.9%	137	67 48.9%	50 36.5%	175	94 53.7%	66 37.7%
United Kingdom	129	76 58.9%	70 54.3%	171	119 69.6%	90 52.6%	196	140 71.4%	100 51.0%
Germany	51	21 41.2%	18 35.3%	169	85 50.3%	65 38.5%	175	109 62.3%	80 45.7%
Italy	19	7 36.8%	6 31.6%	88	35 39.8%	24 27.3%	111	55 49.5%	43 38.7%
France	32	12 37.5%	12 37.5%	93	41 44.1%	30 32.3%	104	55 52.9%	40 38.5%
Spain	29	13 44.8%	12 41.4%	73	27 37.0%	24 32.9%	98	52 53.1%	39 39.8%
Other Europe	169	36 21.3%	67 39.6%	361	166 46.0%	128 35.5%	414	230 55.6%	164 39.6%
Science and engineering									
Europe	359	177 49.3%	162 45.1%	796	383 48.1%	288 36.2%	929	520 56.0%	383 41.2%
Greece	63	27 42.9%	24 38.1%	125	65 52.0%	48 38.4%	158	89 56.3%	62 39.2%
United Kingdom	89	56 62.9%	51 57.3%	103	73 70.9%	53 51.5%	127	90 70.9%	66 52.0%
Germany	27	11 40.7%	9 33.3%	122	59 48.4%	46 37.7%	114	67 58.8%	51 44.7%
Italy	15	5 33.3%	5 33.3%	63	23 36.5%	15 23.8%	81	35 43.2%	28 34.6%
France	16	9 56.2%	9 56.2%	64	25 39.1%	16 25.0%	65	28 43.1%	21 32.3%
Spain	22	10 45.5%	9 40.9%	40	11 27.5%	11 27.5%	57	26 45.6%	19 33.3%
Other Europe	127	59 46.5%	55 43.3%	279	127 45.5%	99 35.5%	327	185 56.6%	136 41.6%
Natural science									
Europe	173	88 50.9%	79 45.7%	419	203 48.4%	159 37.9%	526	300 57.0%	226 43.0%
Greece	29	13 44.8%	11 37.9%	50	27 54.0%	22 44.0%	68	42 61.8%	32 47.1%
United Kingdom	42	28 66.7%	25 59.5%	53	40 75.5%	31 58.5%	74	54 73.0%	45 60.8%
Germany	15	6 40.0%	5 33.3%	76	35 46.1%	25 32.9%	80	45 56.2%	37 46.3%
Italy	9	3 33.3%	3 33.3%	34	11 32.4%	9 26.5%	43	22 51.2%	16 37.2%
France	4	3 75.0%	3 75.0%	26	9 34.6%	5 19.2%	36	16 44.4%	9 25.0%
Spain	11	4 36.4%	3 27.3%	18	4 22.2%	4 22.2%	35	15 42.9%	9 25.7%
Other Europe	63	31 49.2%	29 46.0%	162	77 47.5%	63 38.9%	190	106 55.8%	78 41.1%

(continued)

Appendix table 2–29.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country of origin: 1980, 1990, and 1991
(page 3 of 4)

Region/country	1980					1990					1991				
	Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.		Total Ph.D. recipients	Plan to stay in U.S.		Firm plans to stay in U.S.	
Social science															
Europe	98	40	40.8%	36	36.7%	172	88	51.2%	65	37.8%	218	124	56.9%	96	44.0%
Greece	12	4	33.3%	4	33.3%	18	10	55.6%	6	33.3%	28	12	42.9%	8	28.6%
United Kingdom	28	15	53.6%	13	46.4%	35	23	65.7%	15	42.9%	43	26	60.5%	15	34.9%
Germany	7	2	28.6%	2	28.6%	21	19	90.5%	16	76.2%	27	18	66.7%	14	51.9%
Italy	4	1	25.0%	1	25.0%	15	6	40.0%	3	20.0%	26	11	42.3%	10	38.5%
France	6	2	33.3%	2	33.3%	11	4	36.4%	3	27.3%	10	6	60.0%	8	80.0%
Spain	7	3	42.9%	4	57.1%	14	6	42.9%	6	42.9%	18	10	55.6%	9	50.0%
Other Europe	34	13	38.2%	10	29.4%	58	20	34.5%	16	27.6%	66	41	62.1%	32	48.5%
Engineering															
Europe	88	49	55.7%	47	53.4%	205	92	44.9%	64	31.2%	185	96	51.9%	61	33.0%
Greece	22	10	45.5%	9	40.9%	57	28	49.1%	20	35.1%	62	35	56.5%	22	35.5%
United Kingdom	19	13	68.4%	13	68.4%	15	10	66.7%	7	46.7%	11	10	90.9%	6	54.5%
Germany	5	3	60.0%	2	40.0%	15	5	33.3%	4	26.7%	7	4	57.1%	0	0.0%
Italy	2	1	50.0%	1	50.0%	14	6	42.9%	3	21.4%	12	2	16.7%	2	16.7%
France	4	3	75.0%	3	75.0%	8	1	12.5%	1	12.5%	4	1	25.0%	1	25.0%
Other Europe	30	15	50.0%	17	56.7%	69	30	43.5%	21	30.4%	70	38	54.3%	24	34.3%
All fields															
North & South America	776	191	24.6%	163	21.0%	1,095	434	39.6%	329	30.0%	1,234	597	48.4%	432	35.0%
Canada	301	96	31.9%	89	29.6%	418	191	45.7%	153	36.6%	484	241	49.8%	187	38.6%
Mexico	67	12	17.9%	11	16.4%	130	47	36.2%	32	24.6%	154	71	46.1%	51	33.1%
Argentina	29	13	44.8%	10	34.5%	78	32	41.0%	24	30.8%	71	46	64.8%	33	46.5%
Brazil	156	7	4.5%	3	1.9%	129	22	17.1%	18	14.0%	142	49	34.5%	33	23.2%
Chile	39	10	25.6%	8	20.5%	56	23	41.1%	15	26.8%	65	25	38.5%	20	30.8%
Colombia	29	10	34.5%	9	31.0%	46	24	52.2%	18	39.1%	63	33	52.4%	19	30.2%
Peru	16	6	37.5%	5	31.3%	28	14	50.0%	12	42.9%	39	27	69.2%	16	41.0%
Other N./S. America	139	37	26.6%	28	20.1%	210	81	38.6%	57	27.1%	216	105	48.6%	73	33.8%
Science and engineering															
North & South America	494	127	25.7%	109	22.1%	746	296	39.7%	222	29.8%	817	410	50.2%	308	37.7%
Canada	155	66	42.6%	61	39.4%	251	121	48.2%	99	39.4%	276	161	58.3%	127	46.0%
Mexico	57	10	17.5%	9	15.8%	103	33	32.0%	20	19.4%	126	58	46.0%	45	35.7%
Argentina	25	11	44.0%	9	36.0%	66	28	42.4%	22	33.3%	60	39	65.0%	29	48.3%
Brazil	123	6	4.9%	2	1.6%	98	17	17.3%	13	13.3%	114	35	30.7%	25	21.9%
Chile	26	7	26.9%	5	19.2%	50	18	36.0%	12	24.0%	52	21	40.4%	17	32.7%
Colombia	22	8	36.4%	8	36.4%	40	21	52.5%	16	40.0%	48	24	50.0%	13	27.1%
Peru	11	5	45.5%	4	36.4%	22	10	45.5%	8	36.4%	35	23	65.7%	15	42.9%
Other N./S. America	75	14	18.7%	39	52.0%	116	48	41.4%	32	27.6%	106	49	46.2%	37	34.9%

(continued)

Appendix table 2–29.

Foreign doctoral recipients from U.S. universities who plan to stay in the United States, by field and region/country o. origin: 1980, 1990, and 1991
(page 4 of 4)

	1980			1990			1991		
Region/country	Total Ph.D. recipients	Plan to stay in U.S.	Firm plans to stay in U.S.	Total Ph.D. recipients	Plan to stay in U.S.	Firm plans to stay in U.S.	Total Ph.D. recipients	Plan to stay in U.S.	Firm plans to stay in U.S.
Natural science									
North & South America	272	70 25.7%	60 22.1%	407	153 37.6%	114 28.0%	470	227 48.3%	176 37.4%
Canada	78	38 48.7%	36 46.2%	130	61 46.9%	49 37.7%	148	93 62.8%	76 51.4%
Mexico	33	5 15.2%	4 12.1%	65	19 29.2%	12 18.5%	80	35 43.8%	26 32.5%
Argentina	13	6 46.2%	5 38.5%	43	17 39.5%	13 30.2%	34	21 61.8%	18 52.9%
Brazil	68	3 4.4%	1 1.5%	44	10 22.7%	8 18.2%	64	14 21.9%	11 17.2%
Chile	18	5 27.8%	3 16.7%	22	9 40.9%	6 27.3%	32	16 50.0%	12 37.5%
Colombia	13	2 15.4%	2 15.4%	27	12 44.4%	10 37.0%	26	10 38.5%	6 23.1%
Peru	6	3 50.0%	2 33.3%	11	4 36.4%	4 36.4%	18	9 50.0%	6 33.3%
Other N./S. America	43	8 18.6%	7 16.3%	65	21 32.3%	12 18.5%	68	29 42.6%	21 30.9%
Social science									
North & South America	133	32 24.1%	27 20.3%	179	72 40.2%	56 31.3%	189	87 46.0%	65 34.4%
Canada	57	17 29.8%	14 24.6%	81	38 46.9%	34 42.0%	77	36 46.8%	27 35.1%
Mexico	11	3 27.3%	3 27.3%	13	4 30.8%	1 7.7%	25	13 52.0%	10 40.0%
Argentina	2	0 0.0%	0 0.0%	11	5 45.5%	5 45.5%	14	9 64.3%	5 35.7%
Brazil	31	2 6.5%	1 3.2%	23	2 8.7%	1 4.3%	18	6 33.3%	5 27.8%
Chile	5	1 20.0%	1 20.0%	17	5 29.4%	3 17.6%	12	3 25.0%	3 25.0%
Colombia	6	4 66.7%	4 66.7%	5	4 80.0%	2 40.0%	11	6 54.5%	4 36.4%
Peru	3	0 0.0%	0 0.0%	5	3 60.0%	1 20.0%	10	7 70.0%	5 50.0%
Other N./S. America	18	5 27.8%	4 22.2%	24	11 45.8%	9 37.5%	22	7 31.8%	6 27.3%
Engineering									
North & South America	89	25 28.1%	22 24.7%	40	22 55.0%	16 40.0%	51	32 62.7%	24 47.1%
Canada	20	11 55.0%	11 55.0%	25	10 40.0%	7 28.0%	21	10 47.6%	9 42.9%
Mexico	13	2 15.4%	2 15.4%	12	6 50.0%	4 33.3%	12	9 75.0%	6 50.0%
Argentina	10	5 50.0%	4 40.0%	31	5 16.1%	4 12.9%	32	15 46.9%	9 28.1%
Brazil	24	1 4.2%	0 0.0%	11	4 36.4%	3 27.3%	8	2 25.0%	2 25.0%
Chile	3	1 33.3%	1 33.3%	8	5 62.5%	4 50.0%	11	8 72.7%	3 27.3%
Colombia	3	2 66.7%	2 66.7%	6	3 50.0%	3 50.0%	7	7 100.0%	4 57.1%
Peru	2	2 100.0%	2 100.0%	27	16 59.3%	11 40.7%	16	13 81.2%	10 62.5%
Other N./S. America	14	1 7.14%	0 0	160	71 44.4%	52 32.5%	158	96 60.8%	67 42.4%

NOTES: Those doctoral recipients who plan to stay think that they will locate in the United States; those with firm plans have a postdoctoral research appointment or academic, industrial, or other firm employment in the United States.

[1]Before 1987, there were almost no Chinese doctoral recipients in the United States; therefore, data listed here are for 1987 rather than for 1980.

SOURCE: Science Resources Studies Division, National Science Foundation, *Survey of Earned Doctorates*, unpublished tabulations.

See figure 2–18.

Appendix table 2–30.
Postdoctoral appointments in science and engineering awarded to non-U.S. citizens, by field: 1981 and 1991

	1981			1991		
		Appointments to non-U.S. citizens			Appointments to non-U.S. citizens	
Field	Total	Number	Percent	Total	Number	Percent
Total, all fields	18,411	6,506	35.3	30,432	14,678	48.2
Science and engineering	14,013	5,409	38.6	22,397	11,307	50.5
Natural sciences	11,917	4,453	37.4	19,153	9,492	49.6
Math and computer sciences	205	105	51.2	324	185	57.1
Social sciences	913	175	19.2	967	286	29.6
Engineering	978	676	69.1	1,953	1,344	68.8
Health	4,398	1,097	24.9	8,035	3,371	42.0

SOURCE: Science Resources Studies Division, National Science Foundation, *Foreign Participation in U.S. Academic Science and Engineering: 1991*, NSF 93-302 (Washington, DC: NSF, 1993).

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Appendix table 2–31.

Financial aid awarded to students in higher education: 1982/83–1991/92

Financial aid program	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91 (est)	1991/92 (prel)
	Millions of dollars									
Total	16,359	17,546	18,947	20,170	20,745	23,873	25,511	27,297	28,508	30,771
Total federal programs	13,393	14,160	15,169	15,897	15,942	18,562	19,952	20,627	21,202	22,849
Generally available aid	10,743	12,155	13,413	14,251	14,408	17,060	18,455	19,007	19,694	21,055
Guaranteed loans	6,695	7,576	8,608	8,839	9,102	11,385	11,985	12,151	12,669	13,716
Other federal grants	4,048	4,579	4,805	5,412	5,306	5,675	6,470	6,856	7,025	7,339
Specially directed aid	2,650	2,005	1,756	1,646	1,534	1,502	1,498	1,620	1,508	1,794
Veterans	1,356	1,148	1,004	864	783	762	724	790	678	908
Military	266	297	329	342	361	349	341	364	369	376
Other grants and loans	1,028	560	423	440	390	391	433	466	461	510
State programs	1,006	1,106	1,222	1,311	1,432	1,503	1,581	1,719	1,860	1,931
Institutional and other programs	1,960	2,280	2,556	2,962	3,371	3,808	3,978	4,951	5,446	5,991

SOURCE: L.G. Knapp, *Trends in Student Aid* (Washington, DC: The College Board, 1992).

Science & Engineering Indicators – 1993

Appendix table 2–32.

Financial support to full-time science and engineering graduate students, by source and mechanism: 1983–91

(page 1 of 2)

Source and mechanism	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total support	252,846	254,735	258,241	267,075	271,772	276,225	283,849	288,981	308,669
Fellowships	21,394	21,675	22,672	23,038	22,109	22,638	23,705	24,719	27,188
Traineeships	13,574	13,491	13,469	13,439	13,792	14,238	14,189	14,005	15,560
Research assistantships	54,923	57,771	61,040	66,071	70,221	74,568	79,116	79,595	84,901
Teaching assistantships	60,138	61,344	61,928	62,640	62,932	63,240	64,544	64,194	65,538
Mechanism unknown	102,817	100,454	99,132	101,887	102,718	101,541	102,295	106,468	115,482
Total federal support	47,829	47,842	48,902	51,318	53,315	55,440	57,370	57,875	63,444
Fellowships	4,125	4,128	4,422	4,591	4,437	4,572	5,196	6,240	7,517
Traineeships	9,154	8,989	8,755	8,601	8,713	8,588	8,457	8,300	9,807
Research assistantships	29,144	29,457	30,432	32,747	34,966	36,741	38,552	38,022	40,609
Teaching assistantships	501	403	562	496	439	502	486	605	554
Mechanism unknown	4,905	4,865	4,731	4,883	4,760	5,037	4,679	4,708	4,957
National Science Foundation	9,523	9,850	10,181	10,832	11,241	11,632	11,894	11,949	12,626
Fellowships	1,307	1,340	1,398	1,512	1,489	1,587	1,780	2,085	2,246
Traineeships	61	49	56	27	83	68	84	63	98
Research assistantships	8,066	8,285	8,559	9,089	9,480	9,820	9,869	9,637	10,089
Teaching assistantships	25	28	43	75	27	58	66	86	110
Mechanism unknown	64	148	125	129	162	99	95	78	83
National Institutes of Health	10,840	11,000	11,128	11,895	12,903	13,753	14,473	14,731	16,033
Fellowships	574	613	634	654	693	702	700	827	950
Traineeships	4,483	4,295	4,090	3,945	4,232	4,120	4,096	4,384	4,829
Research assistantships	5,440	5,752	6,107	6,967	7,587	8,537	9,297	9,150	9,869
Teaching assistantships	75	42	59	82	123	117	129	97	90
Mechanism unknown	268	298	238	247	268	277	251	273	295
Other Health & Human Services	4,145	4,113	4,506	4,376	4,137	4,123	3,973	3,548	4,561
Fellowships	202	180	240	172	162	164	216	178	198
Traineeships	3,208	3,218	3,309	3,329	2,967	3,056	2,724	2,263	3,064
Research assistantships	549	583	753	709	825	781	930	988	1,131
Teaching assistantships	37	29	39	28	28	24	10	19	24
Mechanism unknown	149	103	165	138	155	98	93	100	144
Department of Defense	7,010	7,151	7,332	7,943	8,796	9,513	9,190	8,738	9,195
Fellowships	256	240	263	294	349	360	420	565	694
Traineeships	84	62	49	79	137	133	118	105	148
Research assistantships	3,934	4,081	4,195	4,646	5,617	5,995	5,879	5,330	5,458
Teaching assistantships	0	0	0	0	0	0	0	0	0
Mechanism unknown	2,736	2,768	2,825	2,924	2,693	3,025	2,773	2,738	2,895

(continued)

Appendix table 2–32.

Financial support to full-time science and engineering graduate students, by source and mechanism: 1983–91

(page 2 of 2)

Source and mechanism	1983	1984	1985	1986	1987	1988	1989	1990	1991
Other federal	16,311	15,728	15,755	16,272	16,238	16,419	17,840	18,909	21,029
Fellowships	1,786	1,755	1,887	1,959	1,744	1,759	2,080	2,585	3,429
Traineeships	1,318	1,365	1,251	1,221	1,294	1,211	1,435	1,485	1,668
Research assistantships	11,155	10,756	10,818	11,336	11,457	11,608	12,577	12,917	14,062
Teaching assistantships	364	304	421	311	261	303	281	403	330
Mechanism unknown	1,688	1,548	1,378	1,445	1,482	1,538	1,467	1,519	1,540
Nonfederal support	123,246	127,255	131,008	136,214	137,896	140,936	145,501	146,742	153,200
Fellowships	17,269	17,547	18,250	18,447	17,672	18,066	18,509	18,479	19,671
Traineeships	4,420	4,502	4,714	4,838	5,079	5,650	5,732	5,705	5,753
Research assistantships	25,779	28,314	30,608	33,324	35,255	37,827	40,564	41,573	44,292
Teaching assistantships	59,637	60,941	61,366	62,144	62,493	62,738	64,058	63,589	64,984
Mechanism unknown	16,141	15,951	16,070	17,461	17,397	16,655	16,638	17,396	18,500
Self-support	81,771	79,638	78,331	79,543	80,561	79,849	80,978	84,364	92,025
Fellowships	0	0	0	0	0	0	0	0	0
Traineeships	0	0	0	0	0	0	0	0	0
Research assistantships	0	0	0	0	0	0	0	0	0
Teaching assistantships	0	0	0	0	0	0	0	0	0
Mechanism unknown	81,771	79,638	78,331	79,543	80,561	79,849	80,978	84,364	92,025

SOURCE: Science Resources Studies Division, National Science Foundation, *Academic Science and Engineering: Graduate Enrollment and Support, Fall 1991*, Detailed Statistical Tables, NSF 93-309 (Washington, DC: NSF, 1993).

See figure 2–19.

Science & Engineering Indicators – 1993

Appendix table 2–33.

Financial support to full-time science and engineering graduate students, by field and source of major support: 1983–91

(page 1 of 3)

Field and source	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total, all fields	252,846	254,735	258,241	267,075	271,772	276,225	283,849	288,981	308,669
Federal	47,829	47,842	48,902	51,318	53,315	55,440	57,370	57,875	63,444
National Science Foundation	9,523	9,850	10,181	10,832	11,241	11,632	11,894	11,949	12,626
National Institutes of Health	10,840	11,000	11,128	11,895	12,903	13,753	14,473	14,731	16,033
Other Health & Human Services	4,145	4,113	4,506	4,376	4,137	4,123	3,973	3,548	4,561
Department of Defense	7,010	7,151	7,332	7,943	8,796	9,513	9,190	8,738	9,195
Other federal	16,311	15,728	15,755	16,272	16,238	16,419	17,840	18,909	21,029
Nonfederal	123,246	127,255	131,008	136,214	137,896	140,936	145,501	146,742	153,200
Self-support	81,771	79,638	78,331	79,543	80,561	79,849	80,978	84,364	92,025
Total sciences	176,007	176,433	179,126	183,418	186,023	188,593	193,532	197,825	206,668
Federal	30,090	30,398	31,620	32,943	34,007	35,210	36,806	37,473	40,140
National Science Foundation	6,813	7,112	7,454	7,661	7,718	7,776	8,081	8,035	8,295
National Institutes of Health	9,146	9,487	9,590	10,273	10,910	11,788	12,296	12,460	13,369
Other Health & Human Services	1,016	869	1,095	1,019	1,043	925	1,092	1,119	1,275
Department of Defense	2,736	3,065	3,278	3,595	3,972	4,299	3,947	3,700	3,816
Other federal	10,379	9,865	10,203	10,395	10,364	10,422	11,390	12,159	13,385
Nonfederal	92,100	94,028	95,621	98,269	99,336	101,730	104,336	105,267	108,583
Self-support	53,817	52,007	51,885	52,206	52,680	51,653	52,390	55,085	57,945
Physical sciences	25,205	25,852	26,669	27,764	28,414	28,574	29,207	29,042	30,131
Federal	8,126	8,640	8,821	9,523	9,717	9,857	10,247	10,169	10,850
National Science Foundation	3,218	3,406	3,516	3,671	3,590	3,656	3,612	3,547	3,579
National Institutes of Health	1,437	1,506	1,635	1,847	1,930	2,002	1,981	1,929	1,877
Other Health & Human Services	98	122	161	165	167	150	130	127	168
Department of Defense	831	1,011	1,024	1,161	1,292	1,475	1,392	1,203	1,228
Other federal	2,542	2,595	2,485	2,679	2,738	2,574	3,132	3,363	3,998
Nonfederal	15,306	15,531	16,053	16,348	16,694	16,840	17,157	16,909	17,316
Self-support	1,773	1,681	1,795	1,893	2,003	1,877	1,803	1,964	1,965
Environmental sciences	12,068	11,837	11,458	11,347	10,543	10,299	10,143	10,273	10,414
Federal	2,877	2,852	2,960	3,033	2,868	2,799	2,903	2,957	3,085
National Science Foundation	1,325	1,341	1,374	1,357	1,261	1,236	1,253	1,186	1,198
National Institutes of Health	15	30	26	25	24	19	17	21	22
Other Health & Human Services	23	11	15	14	34	32	8	13	33
Department of Defense	365	372	418	453	499	461	435	435	433
Other federal	1,149	1,098	1,127	1,184	1,050	1,051	1,190	1,302	1,399
Nonfederal	5,562	5,644	5,567	5,573	5,227	5,382	5,317	5,216	5,351
Self-support	3,629	3,341	2,931	2,741	2,448	2,118	1,923	2,100	1,978

(continued)

Appendix table 2–33.

Financial support to full-time science and engineering graduate students, by field and source of major support: 1983–91

(page 2 of 3)

Field and source	1983	1984	1985	1986	1987	1988	1989	1990	1991
Agricultural sciences	9,926	9,851	9,191	9,314	9,063	9,072	9,001	9,052	9,238
Federal	1,566	1,406	1,556	1,656	1,719	1,771	1,794	1,775	1,858
National Science Foundation	70	70	96	72	61	50	47	62	62
National Institutes of Health	19	17	17	14	22	31	17	31	28
Other Health & Human Services	6	1	0	1	7	1	11	5	8
Department of Defense	15	17	28	17	30	32	13	18	30
Other federal	1,456	1,301	1,415	1,552	1,599	1,657	1,706	1,659	1,730
Nonfederal	5,845	5,978	5,397	5,432	5,224	5,200	5,110	5,216	5,249
Self-support	2,515	2,467	2,238	2,226	2,120	2,101	2,097	2,061	2,131
Biological sciences	36,862	37,234	37,141	37,917	38,529	39,522	40,680	40,420	42,929
Federal	10,295	10,460	10,731	11,159	11,872	12,524	13,305	13,438	14,501
National Science Foundation	1,062	1,078	1,074	1,081	1,137	1,122	1,256	1,208	1,277
National Institutes of Health	6,809	7,030	7,058	7,537	8,014	8,677	9,279	9,374	10,146
Other Health & Human Services	310	223	357	369	334	267	353	365	495
Department of Defense	243	241	220	189	248	284	257	214	238
Other federal	1,871	1,888	2,022	1,983	2,139	2,174	2,160	2,277	2,345
Nonfederal	19,825	20,227	20,299	20,693	20,845	21,420	22,011	21,968	23,082
Self-support	6,742	6,547	6,111	6,065	5,812	5,578	5,364	5,014	5,346
Mathematics	10,957	11,311	11,818	12,390	13,044	13,514	13,695	13,834	14,259
Federal	760	762	935	999	1,090	1,190	1,221	1,335	1,502
National Science Foundation	223	279	321	357	436	463	475	491	452
National Institutes of Health	28	22	18	19	24	25	28	39	64
Other Health & Human Services	13	4	3	5	6	3	8	10	5
Department of Defense	310	304	386	432	438	513	395	367	376
Other federal	186	153	207	186	186	186	315	428	605
Nonfederal	8,004	8,399	8,655	9,083	9,384	9,748	9,978	10,024	10,137
Self-support	2,193	2,150	2,228	2,308	2,570	2,576	2,496	2,475	2,620
Computer sciences	10,687	11,587	14,101	15,310	15,572	15,393	15,797	16,859	16,552
Federal	1,130	1,269	1,638	1,892	2,084	2,226	2,331	2,412	2,533
National Science Foundation	386	431	502	527	623	634	779	819	906
National Institutes of Health	26	24	20	43	61	64	53	62	65
Other Health & Human Services	3	1	1	2	1	0	7	9	6
Department of Defense	475	630	860	1,037	1,137	1,214	1,164	1,129	1,121
Other federal	240	183	255	283	262	314	328	393	435
Nonfederal	4,050	4,509	5,686	6,127	6,283	6,453	6,626	6,904	6,744
Self-support	5,507	5,809	6,777	7,291	7,205	6,714	6,840	7,543	7,275

(continued)

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Appendix table 2–33.

Financial support to full-time science and engineering graduate students, by field and source of major support: 1983–91

(page 3 of 3)

Field and source	1983	1984	1985	1986	1987	1988	1989	1990	1991
Psychology	26,693	26,102	25,751	26,469	27,308	28,366	29,608	30,694	32,382
Federal	2,141	2,061	2,048	2,031	2,049	2,170	2,215	2,491	2,682
National Science Foundation	190	206	235	231	246	233	236	262	269
National Institutes of Health	600	647	619	586	627	763	720	795	899
Other Health & Human Services	424	396	434	361	379	361	463	486	453
Department of Defense	174	157	140	158	177	153	117	156	163
Other federal	753	655	620	695	620	660	679	792	898
Nonfederal	11,176	11,630	11,887	12,355	12,057	12,347	12,890	13,094	13,500
Self-support	13,376	12,411	11,816	12,083	13,202	13,849	14,503	15,109	16,200
Social sciences	43,609	42,659	42,997	42,907	43,550	43,853	45,401	47,651	50,763
Federal	3,195	2,948	2,931	2,650	2,608	2,673	2,790	2,896	3,129
National Science Foundation	339	301	336	365	364	382	423	460	552
National Institutes of Health	212	211	197	202	208	207	201	209	268
Other Health & Human Services	139	111	124	102	115	111	112	104	107
Department of Defense	323	333	202	148	151	167	174	178	227
Other federal	2,182	1,992	2,072	1,833	1,770	1,806	1,880	1,945	1,975
Nonfederal	22,332	22,110	22,077	22,658	23,622	24,340	25,247	25,936	27,204
Self-support	18,082	17,601	17,989	17,599	17,320	16,840	17,364	18,819	20,430
Total Engineering	53,931	55,157	55,938	60,227	61,885	63,187	64,546	65,692	71,230
Federal	11,970	11,584	11,260	12,377	13,105	14,020	14,258	14,650	16,060
National Science Foundation	2,680	2,696	2,686	3,128	3,474	3,808	3,766	3,868	4,274
National Institutes of Health	477	466	455	449	508	555	644	685	751
Other Health & Human Services	98	78	69	87	114	73	85	103	91
Department of Defense	4,014	3,808	3,774	4,115	4,585	4,970	4,808	4,673	4,874
Other federal	4,701	4,536	4,276	4,598	4,424	4,614	4,955	5,321	6,070
Nonfederal	24,508	26,132	28,055	30,440	31,078	31,637	32,841	33,329	35,333
Self-support	17,453	17,441	16,623	17,410	17,702	17,530	17,447	17,713	19,837

SOURCE: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1991*, NSF 92-335 (Washington, DC: NSF, 1992).

See figure 2–20.

Appendix table 2–34.

Financial support to full-time science and engineering graduate students, by field and type of major support: 1979–91

(page 1 of 2)

Type of major support	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
All science and engineering													
Total	232,376	238,868	242,777	245,378	252,846	254,735	258,241	267,075	271,772	276,225	283,849	288,981	308,669
Fellowships	20,243	20,553	20,136	20,918	21,394	21,675	22,672	23,038	22,109	22,638	23,705	24,719	27,188
Traineeships	18,045	17,529	16,836	14,709	13,574	13,491	13,469	13,439	13,792	14,238	14,189	14,005	15,560
Research assistantships	48,999	51,594	52,752	52,563	54,923	57,771	61,040	66,071	70,221	74,568	79,116	79,595	84,901
Teaching assistantships	51,810	53,913	55,778	58,360	60,138	61,344	61,928	62,640	62,932	63,240	64,544	64,194	65,538
Other types of support	93,279	95,279	97,275	98,828	102,817	100,454	99,132	101,887	102,718	101,541	102,295	106,468	115,482
Physical sciences													
Total	22,535	22,918	23,308	24,038	25,205	25,852	26,669	27,764	28,414	28,574	29,207	29,042	30,131
Fellowships	1,877	1,779	1,820	1,904	1,929	2,091	1,929	1,895	1,847	1,821	1,964	2,251	2,716
Traineeships	453	433	481	433	399	357	418	524	541	502	599	659	777
Research assistantships	7,806	8,340	8,607	8,768	9,145	9,628	10,284	10,994	11,558	12,056	12,426	11,972	12,223
Teaching assistantships	9,950	10,248	10,304	10,711	11,270	11,339	11,467	11,654	11,752	11,600	11,754	11,589	11,717
Other types of support	2,449	2,118	2,096	2,222	2,462	2,437	2,571	2,697	2,716	2,595	2,464	2,571	2,698
Environmental sciences													
Total	10,724	10,969	11,038	11,436	12,068	11,837	11,458	11,347	10,543	10,299	10,143	10,273	10,414
Fellowships	810	876	844	892	880	962	982	848	741	779	770	795	918
Traineeships	316	259	278	263	272	178	176	149	176	153	112	84	93
Research assistantships	3,587	3,770	3,469	3,339	3,545	3,583	3,728	3,838	3,660	3,892	4,169	4,153	4,358
Teaching assistantships	2,614	2,672	2,651	2,849	2,892	2,867	2,649	2,665	2,498	2,553	2,455	2,386	2,370
Other types of support	3,397	3,392	3,796	4,093	4,479	4,247	3,923	3,847	3,468	2,922	2,637	2,855	2,675
Life sciences													
Total	70,966	71,957	71,931	69,953	69,696	70,230	69,509	70,661	71,456	73,039	75,452	74,936	82,938
Fellowships	5,123	5,370	5,377	5,565	5,663	5,776	6,328	6,417	6,383	6,153	6,779	6,870	7,102
Traineeships	12,298	11,952	11,492	10,172	9,419	9,372	9,225	9,243	9,219	9,541	9,292	8,993	10,317
Research assistantships	15,412	15,896	16,344	16,223	16,496	17,576	17,896	19,220	20,225	21,582	23,183	23,403	25,674
Teaching assistantships	12,368	12,654	12,471	12,861	12,621	12,661	12,512	12,209	11,770	11,689	12,013	11,483	12,143
Other types of support	25,765	26,085	26,247	25,132	25,497	24,845	23,548	23,572	23,859	24,074	24,185	24,187	27,702

(continued)

Appendix table 2–34.

Financial support to full-time science and engineering graduate students, by field and type of major support: 1979–91

(page 2 of 2)

Type of major support	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Math and computer sciences													
Total	15,520	16,489	17,599	19,985	21,644	22,898	25,919	27,700	28,616	28,907	29,492	30,693	30,811
Fellowships	1,189	1,061	1,077	1,098	1,182	1,327	1,638	1,739	1,643	1,746	1,848	2,074	2,257
Traineeships	210	214	235	200	174	240	222	242	261	319	346	324	342
Research assistantships	1,642	1,820	1,858	2,036	2,206	2,507	3,074	3,392	3,948	4,273	4,643	4,673	4,897
Teaching assistantships	6,769	7,088	7,530	8,148	8,856	9,372	10,025	10,405	10,865	11,027	11,299	11,505	11,251
Other types of support	5,710	6,306	6,899	8,503	9,226	9,452	10,960	11,922	11,899	11,542	11,356	12,117	12,064
Psychology													
Total	25,859	26,678	26,715	25,812	26,693	26,102	25,751	26,469	27,308	28,366	29,608	30,694	32,382
Fellowships	1,659	1,601	1,304	1,232	1,270	1,295	1,277	1,421	1,417	1,534	1,504	1,656	1,753
Traineeships	2,131	2,008	1,956	1,794	1,383	1,477	1,599	1,325	1,238	1,241	1,182	1,121	1,230
Research assistantships	2,528	2,570	2,890	2,723	2,962	3,027	3,078	3,114	3,218	3,733	3,866	4,051	4,275
Teaching assistantships	4,564	4,773	5,014	4,922	5,007	5,048	5,182	5,365	5,365	5,500	5,763	5,746	5,815
Other types of support	14,977	15,726	15,551	15,141	16,071	15,255	14,615	15,244	16,070	16,358	17,293	18,120	19,309
Social sciences													
Total	46,755	47,137	46,335	44,289	43,609	42,659	42,997	42,907	43,550	43,853	45,401	47,651	50,763
Fellowships	6,120	6,197	5,619	5,602	5,695	5,408	5,774	5,850	5,506	6,143	6,134	5,977	6,717
Traineeships	1,702	1,727	1,449	1,039	1,172	1,134	1,074	1,120	1,456	1,560	1,685	1,835	1,657
Research assistantships	5,207	5,275	5,196	4,866	5,032	5,166	5,080	5,101	5,465	5,580	6,227	6,257	6,711
Teaching assistantships	8,899	9,080	9,521	9,663	9,436	9,498	9,324	9,242	9,578	9,701	10,130	10,599	10,915
Other types of support	24,827	24,858	24,550	23,119	22,274	21,453	21,745	21,594	21,545	20,869	21,225	22,983	24,763
Engineering													
Total	40,017	42,720	45,851	49,865	53,931	55,157	55,938	60,227	61,885	63,187	64,546	65,692	71,230
Fellowships	3,465	3,669	4,095	4,625	4,775	4,816	4,744	4,868	4,572	4,462	4,706	5,096	5,725
Traineeships	935	936	945	808	755	733	755	836	901	922	973	989	1,144
Research assistantships	12,817	13,923	14,388	14,608	15,537	16,284	17,900	20,412	22,147	23,452	24,602	25,086	26,763
Teaching assistantships	6,646	7,398	8,287	9,206	10,056	10,559	10,769	11,100	11,104	11,170	11,130	10,886	11,327
Other types of support	16,154	16,794	18,136	20,618	22,808	22,765	21,770	23,011	23,161	23,181	23,135	23,635	26,271

SOURCE: Science Resources Studies Division, National Science Foundation, *Selected Data on Graduate Students and Postdoctorates in Science and Engineering: Fall 1991*, NSF 92-335 (Washington, DC: NSF, 1992).

See figure 2–21.

Appendix table 3-1.

Total and scientist/engineer employment, by industry: 1980, 1983, 1986, 1989, and 1992

(page 1 of 6)

Industry	Number of jobs				
	1980	1983	1986	1989	1992
	Thousands				
Total industry					
All occupations	66,210	65,457	73,044	79,111	77,622
All scientists and engineers	1,366	1,476	1,642	1,885	1,972
Engineers	992	1,050	1,144	1,290	1,305
Aeronautical/astronautical	27	33	58	65	52
Chemical	45	47	42	42	43
Civil	79	104	94	90	94
Electrical/electronic	273	319	378	459	470
Industrial	133	103	119	119	109
Mechanical	198	198	196	206	208
Other[1]	237	247	257	308	329
Scientists	374	425	497	595	667
Life	19	26	30	46	59
Mathematical	45	59	67	66	71
Physical	108	110	113	122	138
Social	26	29	24	31	43
Computer specialists	175	201	264	330	355
Technicians	1,163	1,308	1,426	1,506	1,474
Manufacturing					
All occupations	20,285	18,432	18,947	19,391	18,040
All scientists and engineers	747	814	926	1,001	973
Engineers	605	670	752	804	767
Aeronautical/astronautical	23	29	52	49	36
Metallurgical, ceramic, materials	9	13	14	14	11
Chemical	33	36	34	31	34
Civil	7	9	8	6	7
Electrical/electronic	159	206	234	256	246
Industrial	123	89	104	104	91
Safety	3	8	6	7	7
Mechanical	126	134	135	142	138
Marine	0	1	1	1	0
Sales	0	26	39	38	35
Other[1]	122	120	126	156	162
Scientists	142	144	174	197	206
Life	16	15	18	23	29
Biological	8	8	9	11	17
Other life scientists	9	7	9	12	9
Mathematical	13	12	14	12	9
Physical	60	57	57	59	61
Physicists and astronomers	2	1	1	1	1
Chemists	56	42	45	48	45
Other physical scientists	2	15	11	11	10
Social	1	1	0	0	0
Computer specialists	52	59	85	103	106
Technicians	531	542	579	586	525
Civil engineering	1	2	2	3	2
Electrical/electronics engineering	131	126	154	150	127
Industrial engineering	17	21	23	23	23
Mechanical engineering	32	36	42	40	38
Drafters	119	119	110	109	101
Other engineering technicians	80	69	72	77	75
Biological, agricultural, and food	11	8	10	10	12
Chemical	0	64	65	66	63
Petroleum	0	1	1	1	1
Other life science technicians	59	14	15	16	12
Computer programmers	81	81	87	92	71

(continued)

Appendix table 3–1.
Total and scientist/engineer employment, by industry: 1980, 1983, 1986, 1989, and 1992
(page 2 of 6)

Industry	Number of jobs				
	1980	1983	1986	1989	1992
	Thousands				
Chemical & allied products, all occupations	1,107	1,043	1,021	1,074	1,083
All scientists and engineers	93	96	96	116	122
Engineers	41	45	43	47	50
Metallurgical, ceramic, materials	0	0	1	1	0
Chemical	19	18	18	18	19
Civil	1	2	1	2	1
Electrical/electronic	3	4	3	6	6
Industrial	4	3	3	4	4
Safety	2	2	2	2	2
Mechanical	9	8	7	6	8
Sales	0	4	2	3	2
Other[1]	4	5	5	5	8
Scientists	52	51	53	69	72
Life	10	11	13	18	24
Mathematical	3	2	1	1	1
Physical	33	32	33	37	36
Computer specialists	6	6	7	14	12
Technicians	52	61	62	66	68
Petroleum refining, all occupations	198	196	169	156	159
All scientists and engineers	12	16	14	13	14
Engineers	9	11	10	9	11
Petroleum	0	0	0	1	1
Chemical	4	5	4	3	4
Civil	0	1	0	1	1
Electrical/electronic	0	1	1	1	1
Industrial	0	1	1	1	0
Safety	0	0	0	0	1
Mechanical	2	2	2	1	2
Other[1]	2	1	1	2	2
Scientists	3	5	5	4	4
Physical	2	3	3	3	3
Computer specialists	1	2	1	2	1
Technicians	5	10	10	8	8
Machinery, all occupations	2,517	2,053	2,074	2,125	1,922
All scientists and engineers	139	147	161	183	163
Engineers	125	130	140	164	148
Metallurgical, ceramic, materials	1	1	2	2	1
Chemical	1	1	1	1	1
Civil	1	1	1	1	1
Electrical/electronic	34	43	50	64	66
Industrial	32	21	17	14	13
Mechanical	37	38	33	40	37
Sales	0	8	15	13	14
Other[1]	18	17	21	29	15
Scientists	14	17	21	20	16
Mathematical	2	3	2	2	1
Physical	1	2	1	0	0
Computer specialists	11	12	19	18	14
Technicians	129	111	116	118	97

(continued)

Appendix table 3–1.
Total and scientist/engineer employment, by industry: 1980, 1983, 1986, 1989, and 1992
(page 3 of 6)

Industry	Number of jobs				
	1980	1983	1986	1989	1992
	Thousands				
Electrical equipment, all occupations	1,771	1,704	1,790	1,744	1,526
All scientists and engineers	170	188	239	161	150
Engineers	153	173	215	148	137
Metallurgical, ceramic, materials	1	2	2	2	1
Chemical	2	3	3	2	2
Civil	0	1	2	2	0
Electrical/electronic	83	106	120	80	75
Industrial	28	19	28	15	15
Safety	0	1	1	1	1
Mechanical	19	19	23	18	16
Sales	0	6	9	8	8
Other[1]	21	17	26	19	18
Scientists	17	15	24	13	14
Mathematical	2	1	2	1	1
Physical	3	3	3	2	2
Computer specialists	10	10	19	10	11
Technicians	123	127	148	108	96
Transportation equipment, all occupations	1,881	1,730	2,003	2,052	1,822
All scientists and engineers	146	176	223	238	229
Engineers	132	159	196	209	202
Aeronautical/astronautical	23	29	52	49	36
Metallurgical, ceramic, materials	1	3	3	3	2
Chemical	1	1	2	1	1
Civil	1	3	2	2	2
Electrical/electronic	14	21	29	29	23
Industrial	22	19	27	33	24
Safety	0	2	2	2	2
Mechanical	20	24	29	26	28
Marine	0	1	1	1	0
Sales	0	2	2	2	2
Other[1]	50	54	48	59	80
Scientists	14	17	28	29	27
Mathematical	5	5	8	7	5
Physical	3	2	3	0	0
Social	1	1	0	0	0
Computer specialists	6	10	16	21	22
Technicians	62	75	87	85	72
Scientific instruments, all occupations	1,022	990	1,018	1,026	925
All scientists and engineers	46	57	60	137	131
Engineers	40	50	52	118	116
Chemical	1	1	1	2	2
Electrical/electronic	19	25	25	67	65
Industrial	6	5	6	14	13
Mechanical	6	7	9	15	16
Sales	0	3	3	4	3
Other[1]	9	8	7	17	16
Scientists	6	7	8	19	15
Mathematical	0	0	1	1	1
Life	1	1	1	2	0
Physical	2	3	2	3	5
Computer specialists	3	3	5	14	10
Technicians	42	46	47	75	70

(continued)

Appendix table 3–1.

Total and scientist/engineer employment, by industry: 1980, 1983, 1986, 1989, 1992

(page 4 of 6)

Industry	Number of jobs				
	1980	1983	1986	1989	1992
	Thousands				
Nonmanufacturing[2]					
All occupations	45,925	47,025	54,097	59,720	59,582
All scientists and engineers	621	709	775	942	1,051
Engineers	387	428	452	545	591
Aeronautical/astronautical	4	4	6	16	16
Chemical	12	11	8	11	9
Civil	73	95	86	84	87
Electrical/electronic	113	113	144	203	224
Industrial	10	14	15	15	18
Mechanical	72	64	61	64	70
Other[1]	102	127	131	152	167
Scientists	234	281	324	397	460
Life	8	11	12	23	29
Mathematical	33	47	53	54	63
Physical	44	53	56	63	77
Social	25	28	24	31	43
Computer specialists	124	142	179	227	249
Technicians	632	766	847	920	950
Mining, all occupations	1,027	952	777	693	631
All scientists and engineers	55	65	55	46	42
Engineers	29	35	30	26	24
Metallurgical, ceramic, materials	1	1	0	1	1
Mining, including mine safety	3	3	3	3	3
Petroleum	15	19	16	11	11
Chemical	1	1	1	1	1
Civil	1	2	1	1	1
Electrical/electronic	2	1	1	1	1
Mechanical	1	3	2	2	2
Sales	0	1	2	2	2
Other[1]	6	4	4	5	3
Scientists	26	31	26	20	18
Physical	21	25	22	16	14
Computer specialists	4	5	4	4	4
Technicians	26	30	26	25	24
Construction, all occupations	4,346	3,948	4,810	5,171	4,471
All scientists and engineers	53	48	32	32	31
Engineers	52	47	31	31	30
Civil	18	19	10	11	11
Electrical/electronic	7	6	5	6	6
Industrial	0	1	1	1	1
Safety	1	1	1	1	1
Mechanical	10	7	5	3	4
Sales	0	8	5	4	4
Other[1]	16	5	4	6	3
Scientists	1	1	1	1	1
Computer specialists	1	1	1	1	1
Technicians	42	34	29	31	29

(continued)

Appendix table 3–1.

Total and scientist/engineer employment, by industry: 1980, 1983, 1986, 1989, 1992

(page 5 of 6)

	Number of jobs				
Industry	1980	1983	1986	1989	1992
			Thousands		
Comm/trans/utilities, all occupations	5,146	4,952	5,247	5,626	5,709
All scientists and engineers	95	102	103	111	113
Engineers	82	81	78	80	80
Aeronautical/astronautical	1	1	1	1	1
Chemical	1	1	1	1	1
Nuclear	1	2	3	3	3
Civil	5	7	8	6	6
Electrical/electronic	43	40	38	39	38
Industrial	4	6	5	4	5
Safety	0	0	1	1	1
Mechanical	7	6	6	5	5
Marine	1	1	1	1	1
Other[1]	18	18	15	20	19
Scientists	13	21	25	31	33
Life	0	0	1	0	1
Mathematical	1	4	2	2	3
Physical	0	0	2	3	3
Social	0	1	2	1	1
Computer specialists	11	16	19	25	25
Technicians	101	121	125	124	124
Trade, all occupations	20,310	20,870	23,641	25,662	25,391
All scientists and engineers	66	66	72	96	106
Engineers	40	36	45	70	75
Chemical	3	0	0	0	0
Electrical/electronic	16	11	16	34	37
Mechanical	18	9	7	7	7
Sales	0	0	15	16	18
Other[1]	3	15	8	13	13
Scientists	26	30	27	26	31
Life	0	1	1	2	2
Mathematical	0	2	0	0	0
Physical	1	2	2	0	3
Computer specialists	25	26	24	25	27
Technicians	122	145	152	143	136
Financial services, all occupations	5,160	5,468	6,273	6,668	6,671
All scientists and engineers	52	73	95	108	123
Engineers	5	8	10	10	16
Safety	0	5	6	5	5
Other[1]	5	3	3	5	11
Scientists	47	64	85	98	108
Mathematical	16	23	27	28	28
Social	2	7	6	5	7
Computer specialists	28	33	52	65	72
Technicians	39	53	63	71	67
Engineering services, all occupations	545	576	681	770	746
All scientists and engineers	125	157	165	194	185
Engineers	115	146	152	173	162
Aeronautical/astronautical	1	2	4	7	6
Metallurgical, ceramic, materials	0	1	1	1	1
Petroleum	1	1	1	1	0
Chemical	5	4	4	6	5
Nuclear	1	2	3	3	3
Civil	46	63	64	62	59

(continued)

Appendix table 3–1.

Total and scientist/engineer employment, by industry: 1980, 1983, 1986, 1989, and 1992

(page 6 of 6)

Industry	Number of jobs				
	1980	1983	1986	1989	1992
	Thousands				
Electrical/electronic	21	25	30	36	34
Industrial	2	3	5	5	5
Safety	1	1	1	3	2
Mechanical	27	27	25	32	30
Marine	1	2	2	2	2
Sales	0	3	2	3	3
Other[1]	8	13	12	14	13
Scientists	11	11	13	21	22
Life	1	1	1	1	1
Mathematical	1	1	1	2	2
Physical	4	4	7	12	13
Social	2	1	1	1	1
Computer specialists	3	3	3	5	6
Technicians	156	199	220	250	233
Computer services, all occupations	304	416	588	736	831
All scientists and engineers	41	59	91	138	168
Engineers	5	11	29	55	69
Electrical/electronic	4	9	25	47	59
Industrial	0	1	1	1	1
Mechanical	0	0	1	1	2
Sales	0	1	1	4	5
Other[1]	1	1	2	2	3
Scientists	37	48	62	84	99
Mathematical	4	5	8	7	9
Physical	0	0	0	1	1
Social	0	0	1	2	2
Computer specialists	33	42	53	74	87
Technicians	51	78	106	131	149

NOTES: Details may not sum to totals because of rounding. Due to revisions in Standard Industrial Classification codes in 1987, employment estimates for 1989 and 1992 may not be strictly comparable with estimates for earlier years.

[1] The "other" engineering category includes a number of smaller fields that are combined in the interest of space. None of these fields individually accounts for more than about 5 percent of the total engineering jobs.

[2] Estimates prior to 1989 exclude noncommercial education and research organizations.

SOURCES: Division of Science Resources Studies, National Science Foundation, and the Bureau of Labor Statistics: unpublished tabulations.

See figures 3–1, 3–2, and 3–3.

Science & Engineering Indicators – 1993

Appendix table 3–2.

Federal scientists and engineers, by occupational field and agency: 1991

Occupational field	All agencies	State	Treasury	Defense	Interior	USDA	Commerce	Labor	HHS	Transportation	Energy	EPA	NASA	TVA	VA	All other agencies
	Number															
Total scientists & engineers	283,780	4,489	7,124	133,673	17,061	33,711	10,942	3,962	11,949	7,207	6,188	6,701	13,902	2,995	7,315	16,561
Scientists	168,909	4,218	6,609	56,756	14,196	31,029	10,084	3,663	11,471	2,001	2,502	4,257	1,769	799	6,192	13,363
Physical sciences	32,556	48	257	9,725	5,311	1,591	4,240	91	2,369	162	1,282	2,630	1,054	211	486	3,099
Math and statistics	6,470	0	77	2,117	78	753	1,645	183	717	77	110	73	256	12	76	296
Computer sciences	53,097	321	5,319	26,932	1,719	2,904	1,767	553	3,580	1,213	490	376	283	480	2,451	4,709
Life sciences	37,437	2	15	2,151	5,726	23,124	847	0	3,313	5	120	1,039	65	77	516	437
Social sciences	22,366	3,838	851	5,082	598	2,417	1,061	1,963	1,042	265	307	81	0	17	655	4,189
Psychology	3,754	0	5	1,178	15	9	4	7	321	61	2	7	38	2	1,823	282
Other	13,229	9	85	9,571	749	231	520	866	129	218	191	51	73	0	185	351
Engineers	114,871	271	515	76,917	2,865	2,682	858	299	478	5,206	3,686	2,444	12,133	2,196	1,123	3,198
Electrical/electronics	35,795	176	54	28,457	316	91	440	51	119	1,540	827	17	2,250	707	47	703
General	21,617	18	270	12,112	288	147	153	9	95	1,001	1,516	45	3,663	410	768	1,122
Civil	15,180	65	6	8,954	1,379	1,875	54	28	15	1,912	332	8	8	262	17	265
Mechanical	13,452	11	50	11,538	203	43	116	16	69	191	194	102	137	456	39	287
Aerospace	9,689	0	0	4,647	1	1	4	0	1	441	0	0	4,579	0	0	15
Industrial	2,863	0	43	2,701	9	13	1	4	9	22	6	1	1	25	11	17
Chemical	1,525	0	6	896	100	37	31	6	19	9	107	174	50	70	0	20
Materials	1,296	0	3	872	17	4	24	0	5	6	14	0	307	0	0	44
Other	13,454	1	83	6,740	552	471	35	185	146	84	690	2,097	1,138	266	241	725
	Percentage change in S&E employment: 1985–91															
Total scientists & engineers	13.9	16.1	71.2	9.6	8.2	10.8	17.0	(4.4)	24.0	18.9	36.8	9.0	22.8	(29.0)	36.2	35.8
Scientists	15.6	13.8	75.4	8.0	10.9	12.9	17.3	(4.6)	23.1	24.5	37.2	1.1	(10.0)	(5.0)	42.7	43.9
Physical sciences	11.5	(20.0)	32.5	6.4	(1.4)	4.3	14.3	(5.2)	10.1	11.7	56.7	(12.0)	(7.1)	6.6	(16.8)	192.1
Math and statistics	(5.7)	(100.0)	(9.4)	(25.5)	13.0	24.9	16.7	11.6	17.5	(3.7)	1.9	14.1	(43.7)	(63.6)	7.0	10.0
Computer sciences	32.3	197.2	83.3	15.8	64.8	59.2	46.6	21.8	24.3	35.8	24.4	68.6	16.9	18.5	90.3	56.3
Life sciences	13.0	(50.0)	(34.8)	19.9	13.1	8.2	31.5	–	45.8	(50.0)	57.9	30.5	25.0	(40.3)	10.3	0.7
Social sciences	9.2	8.9	73.3	7.0	7.2	22.8	(3.1)	(13.9)	2.6	12.3	10.8	3.8	(100.0)	(73.8)	484.8	3.8
Psychology	9.5	(100.0)	(16.7)	1.4	25.0	350.0	(50.0)	600.0	15.1	8.9	–	(12.5)	46.2	(60.0)	8.0	62.1
Other	2.4	28.6	28.8	(0.6)	11.3	24.2	(1.5)	2.5	18.3	16.6	27.3	(3.8)	43.1	(100.0)	44.5	18.2
Engineers	11.6	67.3	30.7	10.9	(3.3)	(8.6)	13.0	(2.3)	50.8	16.9	36.5	26.0	29.6	(35.0)	8.9	9.9
Electrical/electronics	24.1	76.0	86.2	28.0	4.6	(3.2)	21.2	(5.6)	40.0	24.6	11.8	(5.6)	6.2	(12.6)	30.6	10.5
General	10.5	800.0	62.7	2.9	1.4	38.7	10.9	0.0	41.8	18.5	75.7	(8.2)	31.4	(50.2)	8.2	18.0
Civil	(9.5)	12.1	500.0	(13.1)	(5.3)	(9.7)	(15.6)	16.7	0.0	11.9	(5.7)	(33.3)	(69.2)	(37.0)	(43.3)	16.7
Mechanical	(1.0)	450.0	66.7	(1.0)	16.7	(20.4)	13.7	(15.8)	25.5	26.5	54.0	43.7	26.9	(37.9)	(17.0)	10.4
Aerospace	11.4	–	–	7.2	0.0	0.0	(33.3)	–	–	6.8	–	–	16.2	–	–	275.0
Industrial	(6.5)	–	(6.5)	(6.2)	200.0	(27.8)	(80.0)	300.0	28.6	46.7	(64.7)	0.0	(75.0)	(28.6)	22.2	(15.0)
Chemical	(14.3)	–	200.0	(12.1)	5.3	(32.7)	(11.4)	20.0	18.8	(18.2)	(19.5)	7.4	0.0	(56.8)	–	(41.2)
Materials	13.2	–	50.0	15.3	112.5	(50.0)	26.3	–	0.0	50.0	(6.7)	–	8.1	(100.0)	–	33.3
Other	41.8	–	(29.7)	53.1	(13.6)	(9.8)	29.6	(4.6)	117.9	21.7	52.0	29.0	2,609.5	(31.1)	21.1	(2.8)

SOURCES: Office of Personnel Management (OPM), *Occupations of Federal White-Collar and Blue-Collar Workers* (Washington, DC: National Technical Information Services, 1991); OPM, *Occupations of Federal White-Collar and Blue-Collar Workers* (Washington, DC: 1985); and Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See figure 3–4.

Science & Engineering Indicators – 1993

Appendix table 3–3.

Estimated full-time-equivalent scientists and engineers employed in R&D in the United States, by sector: 1969–89

		R&D scientists & engineers			
	Labor force	United States	Industry[1]	All other[2]	Ratio of R&D scientists & engineers to labor force[3]
	Millions	Thousands			
1969	83.0	552.7	385.6	167.1	66.6
1970	84.9	543.8	375.6	168.2	64.1
1971	86.4	523.5	358.6	164.9	60.6
1972	88.8	515.0	354.0	161.0	58.0
1973	91.2	514.6	358.9	155.7	56.4
1974	93.7	520.6	361.7	158.9	55.6
1975	95.5	527.4	363.9	163.5	55.3
1976	97.8	535.2	373.6	161.6	54.7
1977	100.7	560.6	393.6	167.0	55.7
1978	103.9	586.6	414.2	172.4	56.5
1979	106.6	614.5	437.3	177.2	57.7
1980	108.5	651.1	469.2	181.9	60.0
1981	110.3	683.2	498.8	184.4	61.9
1982	111.9	711.8	525.4	186.4	63.6
1983	113.2	751.6	562.5	189.1	66.4
1984	115.2	797.6	603.3	194.3	69.2
1985	117.2	841.6	646.8	194.8	71.8
1986	119.5	882.3	683.4	198.9	73.8
1987	121.6	910.2	702.2	208.0	74.9
1988	123.4	927.3	714.4	212.9	75.2
1989	125.6	949.3	726.0	223.3	75.6

NOTE: Data are based on surveys of employers and include full-time employees plus the full-time equivalent of part-time employees. Data exclude scientists and engineers employed in state and local government agencies.

[1] Industry data include professional R&D personnel employed at industry-administered federally financed R&D centers. Data exclude social scientists.

[2] Estimates are for the Federal Government (including managers of R&D), universities and colleges (including the number of full-time equivalent graduate students receiving stipends and engaged in R&D), other nonprofit institutions, and federally financed R&D centers administered by universities and other nonprofit institutions. Estimates since 1985 exclude military service personnel.

[3] Number of full-time-equivalent scientists and engineers employed in R&D activities per 10,000 labor force population.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1992*, Final Report, NSF 92-330 (Washington, DC, NSF: 1992); and Bureau of Labor Statistics, *Employment and Earnings*.

Science & Engineering Indicators – 1993

Appendix table 3–4.

Doctoral scientists and engineers primarily employed in R&D, by employment sector and degree field: 1991

	Industry				Academia			
Degree field	R&D	Basic research	Applied research	Development	R&D	Basic research	Applied research	Development
	Percent							
Total science and engineering	48.4	3.8	27.5	17.1	36.1	23.7	11.9	0.6
Sciences	46.2	4.5	29.3	12.4	36.4	25.4	10.6	0.4
Physical sciences	55.6	4.8	35.7	15.1	43.1	30.0	11.7	1.4
Chemistry	54.9	4.8	37.9	12.2	37.1	27.6	9.0	0.5
Physics/astronomy	57.2	4.8	30.3	22.2	49.1	32.3	14.4	2.4
Mathematical sciences	44.0	2.6	19.7	21.7	26.2	19.5	5.8	0.9
Mathematics	47.9	2.6	19.0	26.3	25.2	19.4	4.8	1.1
Statistics/probability	31.4	2.4	22.1	6.9	32.1	20.2	11.9	*
Computer/information sciences	58.2	7.3	25.0	25.9	45.8	27.0	18.0	0.8
Environmental sciences	36.2	2.3	30.5	3.3	40.3	29.4	10.5	0.5
Earth sciences	34.6	0.8	31.1	2.7	30.2	22.8	6.9	0.5
Oceanography	42.9	8.2	29.8	5.0	71.4	57.7	13.7	*
Atmospheric sciences	43.5	10.4	24.9	8.3	58.0	30.7	26.8	0.6
Life sciences	44.2	5.8	29.0	9.3	52.3	38.5	13.5	0.3
Biological sciences	45.8	7.9	30.4	7.5	55.5	45.9	9.3	0.3
Agricultural sciences	39.3	0.7	22.9	15.7	50.7	15.9	34.5	0.3
Medical sciences	43.3	3.7	30.4	9.1	39.5	24.5	14.6	0.4
Psychology	23.1	2.0	10.6	10.5	24.4	15.3	9.0	*
Social sciences	21.5	0.8	17.3	3.4	17.8	10.0	7.8	*
Economics	20.6	1.4	18.2	0.9	23.1	10.9	12.1	*
Sociology/anthropology	17.8	0.7	15.4	1.7	17.7	11.3	6.4	*
Other social sciences	24.1	0.5	17.6	6.0	14.5	8.5	6.0	*
Engineering	53.7	2.2	23.3	28.1	33.6	10.8	21.4	1.4
Aeronautical/astronautical	65.4	0.4	34.1	30.8	36.7	15.7	19.8	1.2
Chemical	56.5	1.0	29.3	26.1	34.5	16.2	17.6	0.6
Civil	28.9	1.3	13.2	14.4	17.6	2.1	15.5	*
Electrical/electronic	58.7	1.2	21.9	35.7	33.7	11.2	20.8	1.7
Materials	61.8	4.8	34.4	22.6	34.4	15.8	18.7	*
Mechanical	53.6	4.3	19.4	29.9	29.6	9.5	17.3	2.8
Nuclear	43.4	1.7	15.4	26.3	60.4	10.5	38.1	11.8
Systems design	44.7	*	6.3	38.4	49.6	11.5	38.1	*
Other engineering	47.0	3.5	18.0	25.5	38.5	11.5	26.0	1.0

* = no cases reported

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers: 1991* (Washington, DC: NSF, forthcoming).

See figure 3–6.

Science & Engineering Indicators – 1993

Appendix table 3–5.

Total and R&D employment of U.S. companies' foreign affiliates, by country: 1982 and 1989

Region/country	1982 employment			1989 employment			Change 1982–89	
	Total	R&D	R&D/total	Total	R&D	R&D/total	Total	R&D
	Thousands		Percent	Thousands		Percent	Percent	
All countries	5,022.4	88.5	1.8	5,111.4	95.2	1.9	1.8	7.6
Canada	780.6	8.4	1.1	889.2	10.4	1.2	13.9	23.8
Europe	2,248.5	67.6	3.0	2,308.0	68.0	2.9	2.6	0.6
Belgium	120.3	4.3	3.6	112.8	4.6	4.1	(6.2)	7.0
France	293.2	6.5	2.2	338.1	7.0	2.1	15.3	7.7
Italy	173.4	4.1	2.4	160.9	4.4	2.7	(7.2)	7.3
The Netherlands	104.0	1.9	1.8	123.4	3.5	2.8	18.7	84.2
United Kingdom	729.3	23.3	3.2	741.6	20.2	2.7	1.7	(13.3)
West Germany	502.1	21.4	4.3	491.0	23.8	4.8	(2.2)	11.2
All other European countries	326.2	6.1	1.9	340.2	4.5	1.3	4.3	(26.2)
Japan	82.2	3.1	3.8	131.2	7.8	5.9	59.6	151.6
Latin America & other Western Hemisphere	993.8	4.6	0.5	964.9	4.3	0.4	(2.9)	(6.5)
All other countries	917.3	4.8	0.5	818.1	4.7	0.6	(10.8)	(2.1)

SOURCE: Bureau of Economic Analysis (BEA), Department of Commerce, *U.S. Direct Investment Abroad: 1982 Benchmark Survey Data* (Washington, DC: U.S. Government Printing Office, 1985); and BEA, *U.S. Direct Investment Abroad: 1989 Benchmark Survey, Final Results* (Washington, DC: GPO, 1992).

See figure 3-7.

Science & Engineering Indicators – 1993

Appendix table 3–6.

Total and R&D employment of U.S. companies' foreign affiliates, by industry: 1982 and 1989

Industry	1982 employment			1989 employment			Change 1982–89	
	Total	R&D	R&D/total	Total	R&D	R&D/total	Total	R&D
	Thousands		Percent	Thousands		Percent	Percent	
All industries	5,022.4	88.5	1.8	5,111.4	95.2	1.9	1.8	7.6
Manufacturing	3,357.6	76.2	2.3	3,246.3	78.7	2.4	(3.3)	3.3
Food and kindred products	355.2	3.3	0.9	304.6	3.4	1.1	(14.2)	3.0
Chemicals and allied products	486.7	14.7	3.0	477.2	18.7	3.9	(2.0)	27.2
Industrial chemicals	138.4	3.8	2.7	134.0	5.4	4.0	(3.2)	42.1
Drugs	166.1	7.5	4.5	155.3	9.0	5.8	(6.5)	20.0
All other chemicals	182.2	3.4	1.9	187.9	4.3	2.3	3.1	26.5
Primary and fabricated metals	221.6	1.9	0.9	176.9	1.1	0.6	(20.2)	(42.1)
Machinery, except electrical	440.8	10.9	2.5	504.6	16.0	3.2	14.5	46.8
Office and computing machines	160.2	6.3	3.9	239.0	11.6	4.9	49.2	84.1
All other machinery	280.6	4.6	1.6	265.6	4.4	1.7	(5.3)	(4.3)
Electric and electronic equipment	564.1	14.3	2.5	450.4	8.6	1.9	(20.2)	(39.9)
Transportation equipment	578.6	19.1	3.3	598.8	20.4	3.4	3.5	6.8
Motor vehicles and equipment	546.6	16.7	3.1	566.7	NA	NA	3.7	NA
Other transportation equipment	32.0	2.3	7.2	32.1	NA	NA	0.3	NA
Other manufacturing	710.5	12.0	1.7	733.9	10.6	1.4	3.3	(11.7)
Petroleum	356.0	2.2	0.6	240.9	1.6	0.7	(32.3)	(27.3)
Wholesale trade	427.4	5.7	1.3	498.3	6.7	1.3	16.6	17.5
Finance and services	365.6	3.6	1.0	527.2	6.9	1.3	44.2	91.7
Other industries	515.8	0.8	0.2	598.6	1.2	0.2	16.1	50.0

NA = not available

SOURCES: Bureau of Economic Analysis (BEA), Department of Commerce, *U.S. Direct Investment Abroad: 1982 Benchmark Survey Data* (Washington, DC: Government Printing Office, 1985); and BEA, *U.S. Direct Investment Abroad: 1989 Benchmark Survey, Final Results* (Washington, DC: GPO, 1992).

See figure 3–7.

Science & Engineering Indicators – 1993

Appendix table 3-7.

Employed wage and salary workers who usually work full time, by occupation: 1987 and 1992

Occupation	Employment		Change
	1987	1992	1987–92
	Thousands		Percent
Total, all occupations	80,836	84,143	4.1
Managerial and professional specialty occupations	20,894	23,246	11.3
Executive, administrative, and managerial	10,216	11,287	10.5
Professional specialty occupations	10,678	11,959	12.0
Architects	74	82	10.8
Engineers	1,641	1,594	(2.9)
Aerospace	106	83	(21.7)
Metallurgical and materials	21	21	0.0
Mining	5	4	(20.0)
Petroleum	26	17	(34.6)
Chemical	58	64	10.3
Nuclear	16	6	(62.5)
Civil	200	197	(1.5)
Agricultural	1	2	100.0
Electrical/electronic	513	472	(8.0)
Industrial	225	200	(11.1)
Mechanical	250	286	14.4
Marine and naval architects	11	14	27.3
All other engineers	207	228	10.1
Mathematical and computer scientists	628	861	37.1
Natural scientists	357	402	12.6
Physicists and astronomers	26	23	(11.5)
Chemists, except biochemists	121	120	(0.8)
Atmospheric and space scientists	12	7	(41.7)
Geologists and geodesists	36	47	30.6
All other physical scientists	13	30	130.8
Agricultural and food scientists	25	20	(20.0)
Biological and life scientists	66	81	22.7
Forestry and conservation scientists	22	22	0.0
Medical scientists	36	53	47.2
Physicians	239	294	23.0
Registered nurses	1,125	1,266	12.5
Pharmacists	104	143	37.5
Teachers, college and university	480	495	3.1
Teachers, except college and university	2,894	3,418	18.1
Social scientists and urban planners	217	232	6.9
Economists	92	93	1.1
Psychologists	103	102	(1.0)
Social workers	428	523	22.2
Lawyers	338	381	12.7
Editors and reporters	210	197	(6.2)

SOURCE: Bureau of Labor Statistics, Current Population Survey, unpublished tabulations.

See figure 3-8.

Appendix table 3–8.
Median annual salaries of engineers, by industry: 1987 and 1992

Industry	Salaries 1987	Salaries 1992	Change 1987–92
	Dollars		Percent
All industries	47,150	54,900	16.4
All manufacturing industries	46,050	53,850	16.9
Aerospace	44,950	52,650	17.1
Chemicals, drugs, and plastics	51,000	65,400	28.2
Electric machinery/electronics/computers	43,900	52,250	19.0
Electrical machinery	42,500	48,900	15.1
Electronic equipment	43,800	52,150	19.1
Computers	48,350	56,950	17.8
Fabricated metal products	44,500	47,700	7.2
Nonelectrical machinery	40,250	49,150	22.1
Petroleum	57,000	72,500	27.2
Precision instruments	43,400	52,300	20.5
Other durable goods	45,800	57,800	26.2
Other nondurable goods	45,800	58,900	28.6
All nonmanufacturing industries	48,950	56,150	14.7
Construction	41,750	58,600	40.4
Consulting and engineering services	46,450	57,300	23.4
Electric and gas utilities	47,700	57,500	20.5
Research and development organizations	53,250	63,500	19.2
Other nonmanufacturing	44,950	53,500	19.0

SOURCE: Engineering Workforce Commission, annual survey of engineers' salaries, 1987 and 1992 Special Industry Reports.

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Appendix table 3–9.

Median annual salaries of engineers working in industry, by supervisory status and degree level: 1987 and 1992

Degree level and supervisory status	Salaries 1987	Salaries 1992	Change 1987–92
	Dollars		Percent
All engineers	47,150	54,900	16.4
Supervisor	59,450	70,050	17.8
Nonsupervisor	42,650	50,050	17.4
Bachelors	44,150	52,550	19.0
Supervisor	56,150	67,800	20.7
Nonsupervisor	40,250	48,100	19.5
Masters	51,950	59,350	14.2
Supervisor	63,750	73,100	14.7
Nonsupervisor	46,550	54,150	16.3
Doctorate	59,700	70,600	18.3
Supervisor	70,550	84,600	19.9
Nonsupervisor	55,200	64,550	16.9

SOURCE: Engineering Workforce Commission, annual survey of engineers' salaries, 1987 and 1992 Special Industry Reports.

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Appendix table 3–10.

Civilian defense-related employment, by selected occupation: 1987, 1992, and projected for 1997

	Employment			Change			Change		
Occupation	1987	1992	1997	1987–92	1992–97	1987–97	1987–92	1992–97	1987–97
	Thousands						Percent		
Total, all civilian occupations	5,038.8	4,330.1	3,010.6	(708.7)	(1,319.5)	(2,028.2)	(14.1)	(30.5)	(40.3)
Executive, administrative, and managerial occupations	631.9	549.0	406.0	(82.9)	(143.0)	(225.9)	(13.1)	(26.0)	(35.7)
All professional specialty occupations	724.6	629.7	495.1	(94.9)	(134.6)	(229.5)	(13.1)	(21.4)	(31.7)
Engineers	282.2	227.7	162.2	(54.5)	(65.5)	(120.0)	(19.3)	(28.8)	(42.5)
Aeronautical/astronautical	34.6	26.8	18.3	(7.8)	(8.5)	(16.3)	(22.5)	(31.7)	(47.1)
Chemical	5.0	4.4	3.1	(0.6)	(1.3)	(1.9)	(12.0)	(29.5)	(38.0)
Civil, including traffic	15.0	13.5	10.9	(1.5)	(2.6)	(4.1)	(10.0)	(19.3)	(27.3)
Electrical/electronic	86.4	70.4	51.4	(16.0)	(19.0)	(35.0)	(18.5)	(27.0)	(40.5)
Industrial, except safety	29.3	22.3	14.3	(7.0)	(8.0)	(15.0)	(23.9)	(35.9)	(51.2)
Mechanical	37.4	30.6	21.6	(6.8)	(9.0)	(15.8)	(18.2)	(29.4)	(42.2)
Metallurgical and materials	3.8	3.1	2.1	(0.7)	(1.0)	(1.7)	(18.4)	(32.3)	(44.7)
Mining, including mine safety	0.4	0.4	0.3	0.0	(0.1)	(0.1)	0.0	(25.0)	(25.0)
Nuclear	3.6	3.3	2.5	(0.3)	(0.8)	(1.1)	(8.3)	(24.2)	(30.6)
Petroleum	1.1	1.0	0.8	(0.1)	(0.2)	(0.3)	(9.1)	(20.0)	(27.3)
All other	65.6	51.9	37.0	(13.7)	(14.9)	(28.6)	(20.9)	(28.7)	(43.6)
Life scientists	24.7	23.4	20.6	(1.3)	(2.8)	(4.1)	(5.3)	(12.0)	(16.6)
Computer, mathematical, & operations research analysts	69.8	61.9	54.5	(7.9)	(7.4)	(15.3)	(11.3)	(12.0)	(21.9)
Physical scientists	27.5	25.8	20.8	(1.7)	(5.0)	(6.7)	(6.2)	(19.4)	(24.4)
Chemists	9.4	8.7	6.8	(0.7)	(1.9)	(2.6)	(7.4)	(21.8)	(27.7)
Geologists, geophysicists, and oceanographers	5.7	5.3	4.5	(0.4)	(0.8)	(1.2)	(7.0)	(15.1)	(21.1)
Meteorologists	1.6	1.5	1.3	(0.1)	(0.2)	(0.3)	(6.2)	(13.3)	(18.8)
Physicists and astronomers	5.0	4.9	3.5	(0.1)	(1.4)	(1.5)	(2.0)	(28.6)	(30.0)
All other physical scientists	5.9	5.5	4.8	(0.4)	(0.7)	(1.1)	(6.8)	(12.7)	(18.6)
Social scientists	13.7	13.0	10.7	(0.7)	(2.3)	(3.0)	(5.1)	(17.7)	(21.9)
All other professional specialty occupations	306.7	277.9	226.3	(28.8)	(51.6)	(80.4)	(9.4)	(18.6)	(26.2)
Technicians and related support occupations	288.6	253.5	194.5	(35.1)	(59.0)	(94.1)	(12.2)	(23.3)	(32.6)
All other occupations	3,393.7	2,897.9	1,915.0	(495.8)	(982.9)	(1,478.7)	(14.6)	(33.9)	(43.6)

SOURCE: Bureau of Labor Statistics, unpublished data.

See figure 3–5.

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Appendix table 3–11.

Unemployment rates for selected occupations: 1987–93

Occupation	Annual						Quarterly						
	1987	1988	1989	1990	1991	1992	1st 1992	2nd 1992	3rd 1992	4th 1992	1st 1993	2nd 1993	3rd 1993
	Percent												
Total, all occupations	5.5	4.9	4.7	5.0	6.0	6.7	7.4	6.6	6.5	6.3	7.0	6.1	5.9
Managerial and professional specialty occupations	2.3	1.9	2.0	2.1	2.7	3.1	2.9	3.1	3.5	3.0	3.3	2.9	3.0
Executive, administrative, and managerial occupations	2.6	2.1	2.3	2.3	3.2	3.7	3.6	3.7	4.0	3.7	3.9	3.3	3.2
Professional specialty occupations	2.0	1.7	1.7	1.9	2.3	2.6	2.3	2.6	3.1	2.3	2.7	2.6	2.8
Architects	1.0	1.2	2.4	3.7	6.0	5.6	—	—	—	—	—	—	—
Engineers	2.3	1.6	1.4	2.1	2.6	3.8	4.2	3.9	3.5	3.7	4.0	4.4	3.8
Aerospace	1.5	1.5	0.5	1.9	2.4	4.7	—	—	—	—	—	—	—
Metallurgical and materials	3.0	5.9	0.2	4.2	-0.1	5.6	—	—	—	—	—	—	—
Chemical	1.1	0.7	0.8	1.5	3.0	3.4	—	—	—	—	—	—	—
Civil	3.1	1.3	1.6	1.7	3.3	3.2	—	—	—	—	—	—	—
Electrical/electronic	1.6	1.5	1.3	1.8	2.5	3.5	—	—	—	—	—	—	—
Industrial	2.3	1.5	2.1	3.6	2.1	4.9	—	—	—	—	—	—	—
Mechanical	1.8	1.8	1.3	2.0	1.7	4.7	—	—	—	—	—	—	—
Mathematical and computer scientists	1.9	1.7	1.8	1.5	4.2	2.6	2.3	2.0	2.8	3.2	3.7	2.5	2.2
Natural scientists	2.6	1.0	1.4	1.5	3.3	2.3	2.8	2.0	1.9	2.6	2.7	2.1	3.0
Physicists and astronomers	1.0	1.7	0.2	0.8	2.9	0.0	—	—	—	—	—	—	—
Chemists, except biochemists	1.8	0.6	1.8	1.3	3.3	1.7	—	—	—	—	—	—	—
Geologists and geodesists	6.8	1.9	2.5	1.9	4.7	4.8	—	—	—	—	—	—	—
Agricultural and food scientists	1.4	1.6	2.4	4.0	2.4	2.9	—	—	—	—	—	—	—
Biological and life scientists	2.8	1.7	1.0	2.6	4.0	2.9	—	—	—	—	—	—	—
Medical scientists	0.5	0.9	0.6	0.5	0.7	1.8	—	—	—	—	—	—	—
Physicians	0.5	0.7	0.2	0.4	0.1	0.5	0.1	0.4	0.8	0.5	0.2	1.0	0.9
Registered nurses	0.9	1.2	1.3	1.1	0.9	1.1	0.8	1.0	1.4	1.3	1.3	1.1	1.4
Pharmacists	0.1	0.7	1.1	0.2	0.3	0.8	0.3	1.2	1.6	0.2	0.7	0.0	1.2
Teachers, college and university	1.5	1.8	1.6	2.0	1.4	2.1	0.9	2.3	4.6	1.1	2.0	2.8	3.1
Teachers, except college and university	2.0	1.7	1.7	1.9	1.7	2.1	1.2	1.9	3.4	1.8	1.8	2.1	3.1
Social scientists and urban planners	2.3	2.4	1.9	2.2	3.4	3.3	4.3	4.0	2.8	2.0	3.5	2.8	3.5
Economists	2.7	4.3	2.9	3.2	6.0	5.6	—	—	—	—	—	—	—
Psychologists	1.7	1.2	1.2	1.8	1.7	2.0	—	—	—	—	—	—	—
Social workers	2.9	2.5	2.1	2.4	3.3	3.7	3.7	3.9	3.7	3.3	2.8	2.6	3.9
Lawyers	0.9	0.9	0.9	1.1	0.9	1.2	1.3	1.4	1.4	0.8	0.9	1.6	0.9
Editors and reporters	2.0	2.4	2.0	3.7	2.2	3.1	2.0	4.0	4.0	2.7	3.2	2.2	4.1

— = data are not separately reported here, but are included in totals.

SOURCE: Bureau of Labor Statistics, Current Population Survey, unpublished tabulations.

See figure 3–9.

Appendix table 3–12.

Median annual earnings of wage and salary workers who usually work full time, by selected occupation: 1987 and 1992

Occupation	Earnings 1987	Earnings 1992	Change 1987–92
	Dollars		Percent
Total, all occupations	19,396	23,140	19.3
Managerial and professional specialty occupations	27,144	34,060	25.5
Executive, administrative, and managerial	27,560	33,800	22.6
Professional specialty occupations	26,936	34,268	27.2
Architects	33,124	35,984	8.6
Engineers	37,440	44,824	19.7
Aerospace	39,364	49,244	25.1
Chemical	42,068	51,064	21.4
Civil	34,528	43,160	25.0
Electrical/electronic	38,272	46,384	21.2
Industrial	34,736	40,664	17.1
Mechanical	37,544	42,796	14.0
Mathematical and computer scientists	32,448	41,548	28.0
Natural scientists	31,980	38,012	18.9
Chemists, except biochemists	32,812	39,416	20.1
Biological and life scientists	27,300	34,476	26.3
Physicians	36,296	52,364	44.3
Registered nurses	25,064	34,424	37.3
Pharmacists	35,204	45,032	27.9
Teachers, college and university	33,020	41,548	25.8
Teachers, except college and university	24,440	29,172	19.4
Social scientists and urban planners	27,872	36,660	31.5
Economists	33,020	38,896	17.8
Psychologists	25,116	34,580	37.7
Social workers	21,476	25,428	18.4
Lawyers	42,328	56,420	33.3
Editors and reporters	23,452	30,212	28.8

SOURCE: Bureau of Labor Statistics, Current Population Survey, unpublished tabulations.

See figure 3-10.

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Appendix table 3–13.

Average annual salary offers to bachelors degree candidates, in selected fields: 1988–93

Degree field	Salary offers						Change from				
	1988	1989	1990	1991	1992	1993	1988–89	1989–90	1990–91	1991–92	1992–93
	Dollars						Percent				
Accounting	24,000	25,223	26,391	26,642	27,179	27,493	5.1	4.6	1.0	2.0	1.2
Business administration	21,456	22,450	23,529	24,019	24,305	24,555	4.6	4.8	2.1	1.2	1.0
Communications	20,220	20,819	21,002	21,852	21,262	21,498	3.0	0.9	4.0	(2.7)	1.1
Nursing	23,652	24,915	28,270	29,596	31,732	31,064	5.3	13.5	4.7	7.2	(2.1)
Engineering											
Aerospace/aeronautic	28,176	29,433	30,509	30,667	31,826	31,583	4.5	3.7	0.5	3.8	(0.8)
Chemical	30,996	32,949	35,122	37,492	39,203	39,482	6.3	6.6	6.7	4.6	0.7
Civil	25,596	27,046	28,136	29,658	29,376	29,211	5.7	4.0	5.4	(1.0)	(0.6)
Computer	29,736	30,244	31,490	32,280	32,848	33,963	1.7	4.1	2.5	1.8	3.4
Electrical	29,736	30,594	31,778	33,190	33,754	34,313	2.9	3.9	4.4	1.7	1.7
Industrial	28,476	29,660	30,525	32,131	32,348	32,940	4.2	2.9	5.3	0.7	1.8
Mechanical	29,388	30,490	32,064	33,999	34,462	34,460	3.7	5.2	6.0	1.4	0.0
Petroleum	32,016	32,789	35,202	38,882	40,679	38,387	2.4	7.4	10.5	4.6	(5.6)
Biological sciences	20,364	21,495	21,800	21,917	21,851	21,558	5.6	1.4	0.5	(0.3)	(1.3)
Chemistry	26,004	26,307	27,494	26,836	27,557	28,002	1.2	4.5	(2.4)	2.7	1.6
Computer science	27,408	28,659	29,804	30,696	30,523	31,329	4.6	4.0	3.0	(0.6)	2.6
Mathematics	26,724	26,407	27,032	27,370	28,434	26,524	(1.2)	2.4	1.3	3.9	(6.7)
Physics	27,816	28,022	28,022	29,227	29,019	26,835	0.7	0.0	4.3	(0.7)	(7.5)
Psychology	20,592	19,400	20,688	20,541	20,180	20,571	(5.8)	6.6	(0.7)	(1.8)	1.9
Sociology	NA	18,979	20,134	20,341	21,015	22,079	NA	6.1	1.0	3.3	5.1

NA = not available

SOURCE: College Placement Council, Survey of Beginning Salary Offers, annual series.

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Appendix table 3–14.

Employed doctoral scientists and engineers, by degree field and type of employer: 1991

Degree field	Total	Industry	Educational institutions	Federal Government	State & local government	Nonprofit organizations	Other
Total science and engineering	437,206	157,256	206,225	27,610	10,357	15,848	19,910
Sciences	367,440	117,650	183,278	23,794	9,948	13,929	18,841
Physical sciences	80,872	42,086	29,368	5,006	604	2,461	1,347
Mathematical sciences	20,049	4,094	14,280	945	57	465	208
Computer specialties	5,376	2,638	2,494	65	NA	82	NA
Environmental sciences	13,263	3,729	5,508	2,568	777	473	208
Life sciences	113,743	29,619	62,767	9,060	2,654	4,150	5,493
Psychology	65,672	24,080	24,850	1,775	2,692	2,975	9,300
Social sciences	68,465	11,404	44,011	4,375	3,164	3,323	2,188
Engineering	69,766	39,606	22,947	3,816	409	1,919	1,069
Astronautical/aeronautical	3,087	1,664	1,059	247	0	83	34
Chemical	10,633	7,427	2,369	296	0	341	200
Civil	7,512	3,393	3,068	609	203	145	94
Electrical/electronic	16,994	10,116	5,458	688	10	549	173
Mechanical	8,680	4,773	2,931	600	33	257	86
Other engineering	22,860	12,233	8,062	1,376	163	544	482

NA = not available

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers: 1991* (Washington, DC: NSF, forthcoming).

See figure 3-11.

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Appendix table 3–15.

Median annual salaries of full-time employed doctoral scientists and engineers, by degree field and type of employer: 1991

Degree field	Total employed	Industry	Educational institutions	Federal Government	Nonprofit organizations
Total science and engineering	60,700	70,200	56,300	60,300	59,600
Sciences	59,000	69,000	55,200	59,700	55,600
Physical sciences	65,100	68,800	61,100	61,700	63,500
Chemistry	63,200	66,900	56,500	61,300	57,500
Physics/astronomy	67,100	73,000	64,500	62,700	65,900
Mathematical sciences	60,800	70,700	56,700	70,300	*
Mathematics	60,100	70,600	55,800	74,200	*
Statistics/probability	62,400	70,800	60,000	*	*
Computer and information sciences	68,100	75,600	63,600	*	*
Environmental sciences	60,200	70,300	55,600	62,200	55,900
Earth sciences	60,300	72,100	55,400	62,700	*
Oceanography	60,400	67,400	56,000	60,300	*
Atmospheric sciences	58,300	*	51,900	*	*
Life sciences	55,500	65,200	52,100	54,500	56,700
Biological sciences	55,500	65,500	52,000	54,500	56,400
Agricultural sciences	51,500	55,600	50,100	54,200	*
Medical sciences	59,500	70,900	55,000	57,000	59,800
Psychology	55,500	70,500	53,400	54,700	50,000
Social sciences	56,000	70,500	55,000	66,000	52,400
Economics	64,200	90,200	60,400	68,500	*
Sociology/anthropology	50,500	50,000	51,300	52,400	40,500
Other social sciences	55,200	73,000	52,400	67,400	56,000
Engineering	70,200	71,400	67,800	65,400	72,200
Aeronautical/astronautical	73,200	75,600	72,300	*	*
Chemical	71,400	74,400	66,200	*	*
Civil	65,200	64,900	66,400	63,900	*
Electrical/electronic	74,200	75,900	72,800	70,800	70,400
Materials	64,800	62,900	70,700	*	*
Mechanical	68,900	73,200	67,200	59,900	*
Nuclear	70,400	67,700	70,500	*	*
Systems design	71,300	72,800	69,000	*	*
Other engineering	68,000	70,500	66,400	61,200	*

* = no medians were computed for groups with fewer than 20 individuals reporting salary

SOURCE: Science Resources Studies Division, National Science Foundation, *Characteristics of Doctoral Scientists and Engineers: 1991* (Washington, DC: NSF, forthcoming).

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Appendix table 3–16.

Employed wage and salary workers who usually work full time, by selected occupation and sex: 1983 and 1992

Occupation	1983				1992			
	Employment			Women as proportion of total employment	Employment			Women as proportion of total employment
	Total	Men	Women		Total	Men	Women	
	Thousands			Percent	Thousands			Percent
Total, all occupations	70,976	42,309	28,667	40.4	84,143	47,877	36,266	43.1
Managerial and professional specialty occupations	7,451	10,312	7,139	40.9	23,246	12,082	11,165	48.0
Executive, administrative, and managerial occupations	8,117	5,344	2,772	34.2	11,287	6,370	4,918	43.6
Professional specialty occupations	9,334	4,967	4,367	46.8	11,959	5,712	6,247	52.2
Architects	60	53	8	13.3	82	72	10	12.2
Engineers	1,487	1,398	88	5.9	1,594	1,456	139	8.7
Aerospace	82	76	6	7.3	83	78	5	6.0
Metallurgical and materials	27	25	2	7.4	21	20	1	4.8
Mining	7	7	0	0.0	4	4	0	0.0
Petroleum	33	30	3	9.1	17	16	1	5.9
Chemical	67	64	4	6.0	64	61	3	4.7
Nuclear	15	15	0	0.0	6	5	1	16.7
Civil	187	180	7	3.7	197	182	15	7.6
Agricultural	4	4	0	0.0	2	2	1	50.0
Electrical/electronic	427	399	28	6.6	472	434	38	8.1
Industrial	204	182	22	10.8	200	170	29	14.5
Mechanical	243	234	8	3.3	286	273	13	4.5
Marine and naval architects	12	12	0	0.0	14	14	0	0.0
All other engineers	178	170	8	4.5	228	196	32	14.0
Mathematical and computer scientist	421	296	125	29.7	861	572	289	33.6
Natural scientists	318	258	61	19.2	402	289	113	28.1
Physicists and astronomers	31	29	2	6.5	23	20	3	13.0
Chemists, except biochemists	99	77	22	22.2	120	84	36	30.0
Atmospheric and space scientists	10	10	0	0.0	7	7	0	0.0
Geologists and geodesists	49	40	8	16.3	47	42	5	10.6
All other physical scientists	8	6	2	25.0	30	19	11	36.7
Agricultural and food scientists	24	22	2	8.3	20	15	4	20.0
Biological and life scientists	50	32	19	38.0	81	49	32	39.5
Forestry and conservation scientists	31	31	0	0.0	22	18	4	18.2
Medical scientists	17	12	5	29.4	53	34	18	34.0
Physicians	224	173	51	22.8	294	217	77	26.2
Registered nurses	953	53	900	94.4	1,266	82	1,184	93.5
Pharmacists	108	78	30	27.8	143	83	61	42.7
Teachers, college and university	414	296	118	28.5	495	328	167	33.7
Teachers, except college and university	2,673	855	1,818	68.0	3,418	916	2,502	73.2
Social scientists and urban planners	194	111	82	42.3	232	113	118	50.9
Economists	85	54	31	36.5	93	49	44	47.3
Psychologists	89	41	48	53.9	102	43	60	58.8
Social workers	358	133	225	62.8	523	172	351	67.1
Lawyers	287	229	58	20.2	381	263	117	30.7
Editors and reporters	165	87	78	47.3	197	105	92	46.7

NOTE: Details may not sum to totals because of rounding.

SOURCE: Bureau of Labor Statistics, Current Population Survey, unpublished tabulations.

See figure 3-12.

Appendix table 3–17.

Employed wage and salary workers who usually work full time, by selected occupation and race/ethnicity: 1983 and 1992

Occupation	Employment					Proportion of total employment		
	Total	White	Black	Hispanic origin	Other	Black	Hispanic origin	Other
	Thousands					Percent		
1983								
Total, all occupations	70,976	61,739	7,373	4,127	1,864	10.4	5.8	2.6
Managerial and professional specialty occupations	17,451	15,843	1,100	472	508	6.3	2.7	2.9
Executive, administrative, and managerial	8,117	7,513	424	230	180	5.2	2.8	2.2
Professional specialty occupations	9,334	8,331	676	242	327	7.2	2.6	3.5
Engineers	1,487	1,369	38	33	80	2.6	2.2	5.4
Mathematical and computer scientists	421	380	22	11	19	5.2	2.6	4.5
Natural scientists	318	287	10	6	21	3.1	1.9	6.6
Health-diagnosing occupations	254	215	8	13	31	3.1	5.1	12.2
Health assessment and treating	1,340	1,143	117	31	80	8.7	2.3	6.0
Teachers, college and university	414	382	16	5	16	3.9	1.2	3.9
Teachers, except college and university	2,673	2,378	263	77	32	9.8	2.9	1.2
Lawyers and judges	321	306	9	5	6	2.8	1.6	1.9
Other professional specialties	2,106	1,871	192	60	43	9.1	2.8	2.0
Engineering and science technicians	945	848	65	32	32	6.9	3.4	3.4
All other occupations	52,580	45,048	6,208	3,623	1,324	11.8	6.9	2.5
1992								
Total, all occupations	84,143	71,630	9,537	6,986	2,976	11.3	8.3	3.5
Managerial and professional specialty occupations	23,247	20,617	1,708	952	922	7.3	4.1	4.0
Executive, administrative, and managerial	11,288	10,205	746	495	337	6.6	4.4	3.0
Professional specialty occupations	11,959	10,467	962	456	530	8.0	3.8	4.4
Engineers	1,594	1,407	64	49	123	4.0	3.1	7.7
Mathematical and computer scientists	861	736	61	28	64	7.1	3.3	7.4
Natural scientists	402	362	11	12	29	2.7	3.0	7.2
Health-diagnosing occupations	341	284	16	19	41	4.7	5.6	12.0
Health assessment and treating	1,791	1,497	189	63	105	10.6	3.5	5.9
Teachers, college and university	495	440	24	13	31	4.8	2.6	6.3
Teachers, except college and university	3,418	3,038	325	123	55	9.5	3.6	1.6
Lawyers and judges	412	384	21	12	7	5.1	2.9	1.7
Other professional specialties	2,645	2,319	251	136	75	9.5	5.1	2.8
Engineering and science technicians	1,044	912	83	49	49	8.0	4.7	4.7
All other occupations	59,852	50,101	7,746	5,985	2,005	12.9	10.0	3.3

NOTE: Details may not sum to totals because of rounding.

SOURCE: Bureau of Labor Statistics, Current Population Survey, unpublished tabulations.

See figure 3-14.

Appendix table 3–18.

Immigrant scientists and engineers, by region/country of birth and occupation: 1976 and 1982–92

(page 1 of 2)

Region/country	1976	1982	1983	1984	1985	1987	1989	1990	1991	1992	1976	1982	1983	1984	1985	1987	1989	1990	1991	1992
	Number										Percentage of total									
All scientists and engineers																				
All regions/countries	7,782	12,188	10,566	9,502	10,980	11,316	11,868	12,659	14,111	22,871	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Western Europe	1,147	1,677	1,684	1,557	1,604	1,657	1,642	2,045	1,506	2,700	14.7	13.8	15.9	16.4	14.6	14.6	13.8	16.2	10.7	11.8
Eastern Europe	994	1,247	658	740	830	682	1,039	1,463	2,553	2,806	12.8	10.2	6.2	7.8	7.6	6.0	8.8	11.6	18.1	12.3
Near & Middle East	429	1,218	1,229	1,289	1,428	1,329	1,305	1,287	1,278	1,592	5.5	10.0	11.6	13.6	13.0	11.7	11.0	10.2	9.1	7.0
Far East	4,058	5,711	4,922	4,049	4,942	5,272	5,596	5,382	6,317	12,669	52.1	46.9	46.6	42.6	45.0	46.6	47.2	42.5	44.8	55.4
Africa	322	577	537	450	498	570	510	551	551	699	4.1	4.7	5.1	4.7	4.5	5.0	4.3	4.4	3.9	3.1
Canada	178	340	282	248	330	378	304	432	339	512	2.3	2.8	2.7	2.6	3.0	3.3	2.6	3.4	2.4	2.2
S. America & Mexico	310	661	646	606	685	708	745	742	739	1,041	4.0	5.4	6.1	6.4	6.2	6.8	6.3	5.9	5.2	4.6
All other areas	344	757	608	563	663	660	727	757	828	852	4.4	6.2	5.8	5.9	6.0	5.8	6.1	6.0	5.9	3.7
Natural scientists																				
All regions/countries	1,527	1,756	1,451	1,173	1,342	1,292	1,238	1,231	1,298	2,796	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Western Europe	286	261	261	225	252	269	233	293	197	419	18.7	14.9	18.0	19.2	18.8	20.8	18.8	23.8	15.2	15.0
Eastern Europe	133	125	89	101	138	94	139	127	241	360	8.7	7.1	6.1	8.6	10.3	7.3	11.2	10.3	18.6	12.9
Near & Middle East	58	116	94	107	112	91	88	87	97	136	3.8	6.6	6.5	9.1	8.3	7.0	7.1	7.1	7.5	4.9
Far East	784	774	670	463	509	499	503	435	502	1,528	51.3	44.1	46.2	39.5	37.9	38.6	40.6	35.3	38.7	54.6
Africa	67	102	101	72	68	83	63	72	61	96	4.4	5.8	7.0	6.1	5.1	6.4	5.1	5.8	4.7	3.4
Canada	51	79	55	42	57	69	42	59	43	60	3.3	4.5	3.8	3.6	4.2	5.3	3.4	4.8	3.3	2.1
S. America & Mexico	64	128	80	74	90	87	108	91	91	116	4.2	7.3	5.5	6.3	6.7	6.7	8.7	7.4	7.0	4.1
All other areas	84	171	101	89	116	100	62	67	66	81	5.5	9.7	7.0	7.6	8.6	7.7	5.0	5.4	5.1	2.9
Mathematical scientists & computer specialists																				
All regions/countries	497	1,805	975	732	999	1,176	1,515	1,613	1,722	3,402	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Western Europe	82	255	186	160	173	191	188	282	189	382	16.5	14.1	19.1	21.9	17.3	16.2	12.4	17.5	11.0	11.2
Eastern Europe	34	146	47	35	36	35	60	141	150	151	6.8	8.1	4.8	4.8	3.6	3.0	4.0	8.7	8.7	4.4
Near & Middle East	42	165	93	78	105	102	114	105	130	173	8.5	9.1	9.5	10.7	10.5	8.7	7.5	6.5	7.5	5.1
Far East	266	902	473	310	495	623	846	757	919	2,266	53.5	50.0	48.5	42.3	49.5	53.0	55.8	46.9	53.4	66.6
Africa	15	83	46	40	41	37	69	65	70	109	3.0	4.6	4.7	5.5	4.1	3.1	4.6	4.0	4.1	3.2
Canada	21	81	37	28	41	51	62	79	63	76	4.2	4.5	3.8	3.8	4.1	4.3	4.1	4.9	3.7	2.2
S. America & Mexico	20	77	47	41	46	66	86	68	79	138	4.0	4.3	4.8	5.6	4.6	5.6	5.7	4.2	4.6	4.1
All other areas	17	96	46	40	62	71	90	116	122	107	3.4	5.3	4.7	5.5	6.2	6.0	5.9	7.2	7.1	3.1

(continued)

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Appendix table 3–18.

Immigrant scientists and engineers, by region/country of birth and occupation: 1976 and 1982–92

(page 2 of 2)

Region/country	1976	1982	1983	1984	1985	1987	1989	1990	1991	1992	1976	1982	1983	1984	1985	1987	1989	1990	1991	1992
	Number										Percentage of total									
Social scientists																				
All regions/countries	612	747	337	316	506	508	449	528	599	1088	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Western Europe	122	148	69	51	82	95	71	72	51	96	19.9	19.8	20.5	16.1	16.2	18.7	15.8	13.6	8.5	8.8
Eastern Europe	125	107	42	58	121	121	101	154	262	567	20.4	14.3	12.5	18.4	23.9	23.8	22.5	29.2	43.7	52.1
Near & Middle East	38	80	27	30	51	39	38	46	30	29	6.2	10.7	8.0	9.5	10.1	7.7	8.5	8.7	5.0	2.7
Far East	172	189	71	54	79	74	60	57	71	144	28.1	25.3	21.1	17.1	15.6	14.6	13.4	10.8	11.9	13.2
Africa	39	40	18	10	21	35	18	20	29	30	6.4	5.4	5.3	3.2	4.2	6.9	4.0	3.8	4.8	2.8
Canada	38	34	10	14	23	27	19	29	13	23	6.2	4.6	3.0	4.4	4.5	5.3	4.2	5.5	2.2	2.1
S. America & Mexico	31	68	41	62	73	69	72	74	71	102	5.1	9.1	12.2	19.6	14.4	13.6	16.0	14.0	11.9	9.4
All other areas	47	81	59	37	56	48	70	76	72	97	7.7	10.8	17.5	11.7	11.1	9.4	15.6	14.4	12.0	8.9
Engineers																				
All regions/countries	5,146	7,880	7,803	7,281	8,133	8,340	8,666	9,287	10,492	15,585	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Western Europe	657	1,013	1,168	1,121	1,097	1,102	1,150	1,398	1,069	1,803	12.8	12.9	15.0	15.4	13.5	13.2	13.3	15.1	10.2	11.6
Eastern Europe	702	869	480	546	535	432	739	1,041	1,900	1,728	13.6	11.0	6.2	7.5	6.6	5.2	8.5	11.2	18.1	11.1
Near & Middle East	291	857	1,015	1,074	1,160	1,097	1,065	1,049	1,021	1,254	5.7	10.9	13.0	14.8	14.3	13.2	12.3	11.3	9.7	8.0
Far East	2,836	3,846	3,708	3,222	3,859	4,076	4,187	4,133	4,825	8,731	55.1	48.8	47.5	44.3	47.4	48.9	48.3	44.5	46.0	56.0
Africa	201	352	372	328	368	415	360	394	391	464	3.9	4.5	4.8	4.5	4.5	5.0	4.2	4.2	3.7	3.0
Canada	68	146	180	164	209	231	181	265	220	353	1.3	1.9	2.3	2.3	2.6	2.8	2.1	2.9	2.1	2.3
S. America & Mexico	195	388	478	429	476	546	479	509	498	685	3.8	4.9	6.1	5.9	5.9	6.5	5.5	5.5	4.7	4.4
All other areas	196	409	402	397	429	441	505	498	568	567	3.8	5.2	5.2	5.5	5.3	5.3	5.8	5.4	5.4	3.6

NOTE: Data for 1986 and 1988 are unavailable.

SOURCE: Science Resources Studies Division (SRS), National Science Foundation, *Immigrant Scientists, Engineers, and Technicians: 1991-92* (Washington, DC: NSF, forthcoming); and SRS, annual series.

See figures 3-15 and 3-16.

Science & Engineering Indicators – 1993

Appendix table 3–19.

Nonacademic scientists and engineers per 10,000 labor force for selected countries, by sex: Most current year

	France (1992)	West Germany (1987)	Japan (1990)	United Kingdom[1] (1990)	Canada (1986)	Sweden (1985)	Italy (1981)	United States[2] (1992)
Labor force	22,329,942	26,907,517	61,733,800	24,266,828	11,702,215	4,285,109	20,246,000	117,598,000
Nonacademic employment of scientists and engineers								
Total scientists and engineers	582,947	671,338	2,345,000	796,283	312,160	223,876	124,290	3,502,000
Male	480,043	623,347	2,195,600	696,494	248,610	198,825	110,137	2,719,000
Female	102,904	47,991	149,400	99,781	63,550	25,051	14,153	783,000
Scientists	286,375	126,858	654,500	342,334	177,840	63,431	63,402	1,749,000
Male	205,335	101,000	551,700	264,877	122,175	45,216	50,093	1,114,000
Female	81,040	25,858	102,800	77,454	55,665	18,215	13,309	634,000
Engineers	296,572	544,480	16,905,000	453,949	134,320	160,445	60,888	1,753,000
Male	274,708	522,347	1,643,900	431,617	126,435	153,609	60,044	1,605,000
Female	21,864	22,133	46,600	22,327	7,885	6,836	844	149,000
Employment per 10,000 labor force								
Total scientists and engineers	261	249	380	328	267	522	61	298
Male	215	232	356	287	212	464	54	231
Female	46	18	24	41	54	58	7	67
Scientists	128	47	106	141	152	148	31	149
Male	92	38	89	109	104	106	25	95
Female	36	10	17	32	48	43	7	54
Engineers	133	202	274	187	115	374	30	149
Male	123	194	266	178	108	358	30	136
Female	10	8	8	9	7	16	*	13

* = fewer than 1 per 10,000

NOTES: Figures refer to scientists and engineers employed in science and engineering jobs. Because of rounding, details may not sum to totals. The numbers of scientists and engineers for France, West Germany, Japan, Canada, Sweden, Italy, and the United Kingdom are estimates prepared by the Bureau of the Census based on published and unpublished census and survey data for the years shown. Labor force data are from the Organisation for Economic Co-operation and Development, and thus the number of scientists and engineers per 10,000 labor force differs from data published in Census Bureau reports.

[1] Data exclude Northern Ireland.

[2] Data by sex are estimates.

SOURCES: Bureau of Labor Statistics, Occupational Employment Survey; Bureau of the Census; and Science Resources Division, National Science Foundation, unpublished tabulations.

Science & Engineering Indicators – 1993

Appendix table 3–20.

Nonacademic scientists and engineers in selected countries, by sector of employment: Most current year

Sector	Canada (1986)	France (1992)	West Germany (1985)	Japan (1990)	Sweden (1985)	United Kingdom (1990)	United States (1992)
	Percent						
Scientists							
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture	3.4	0.3	0.2	0.2	0.6	1.7	0.8
Mining	4.4	1.8	[2]	0.0	0.3	1.6	1.5
Manufacturing	14.1	19.3	43.0	23.0	25.0	30.9	22.2
Construction	0.5	0.5	0.9	0.4	1.7	0.7	0.2
Wholesale and retail trade	4.8	6.0	2.2	0.5	10.0	4.4	3.1
Transportation, communications, and public utilities	7.6	2.5	2.9	0.5	5.3	6.8	4.0
Business and professional services	21.3	43.6	39.7	73.7	28.6	25.0	48.2
Government	NA	NA	7.4	1.6	NA	NA	19.6
All other	44.1	25.9	3.7	0.0	28.5	28.9	—
Engineers							
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture	0.7	0.0	0.1	0.2	0.4	0.0	0.1
Mining	6.1	4.3	[2]	0.1	0.8	2.4	1.7
Manufacturing	30.8	43.2	43.9	30.6	47.8	48.6	48.4
Construction	4.6	8.1	10.5	21.7	16.9	10.1	2.0
Wholesale and retail trade	2.0	5.5	1.9	3.2	5.1	3.5	4.2
Transportation, communications, and public utilities	14.4	8.1	10.1	4.2	8.3	9.3	5.7
Business and professional services	28.1	15.8	21.0	37.0	12.2	18.8	22.8
Government	NA	NA	12.0	3.1	NA	NA	14.3
All other	13.2	15.0	0.5	0.0	8.6	7.2	—

— = less than 0.05 percent; NA = not available, but included in "all other" category.

[1] Data exclude Northern Ireland.

[2] Mining data are included under transportation, communications, and public utilities.

NOTES: Figures refer to scientists and engineers employed in science and engineering jobs. Because of rounding, details may not sum to 100 percent. Figures for France, West Germany, Japan, Canada, Sweden, and the United Kingdom are estimates prepared by the U.S. Bureau of the Census based on published and unpublished census and survey data for the year shown.

SOURCES: Bureau of Labor Statistics, Occupational Employment Survey; Bureau of the Census; and Science Resources Division, National Science Foundation, unpublished tabulations.

Science & Engineering Indicators – 1993

Appendix table 3–21.

Scientists and engineers in manufacturing for selected countries, by occupation group: Most current year

Occupation	Canada (1986)	France (1992)	West Germany (1985)	Japan (1985)	Sweden (1985)	United Kingdom[1] (1990)	United States (1992)
	Percent						
Total scientists and engineers	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Scientists	39.3	30.2	18.4	25.7	19.1	32.4	21.2
Natural	11.3	8.8	10.9	4.4	5.4	10.0	9.3
Computer	24.4	20.0	[2]	21.2	8.4	22.4	11.9
Social/other	3.6	1.4	7.4	0.1	5.3	0.0	0.0
Engineers	60.7	69.8	81.6	74.3	80.9	67.6	78.8
Civil	4.1	2.2	25.9	32.1	2.2	0.8	0.7
Electrical/electronic	15.0	26.9	13.0	15.4	20.2	16.8	25.3
Industrial/mechanical/other	41.6	40.8	42.8	26.8	58.5	50.0	52.8

[1] Data exclude Northern Ireland.

[2] Systems analysts are included with natural scientists; computer engineers are included with electrical/electronic engineers.

NOTES: Figures refer to scientists and engineers employed in science and engineering jobs. Details may not sum to totals because of rounding. Figures for France, West Germany, Japan, Canada, Sweden, and the United Kingdom are estimates prepared by the U.S. Bureau of the Census based on published and unpublished census and survey data for the years shown.

SOURCES: Bureau of Labor Statistics, Occupational Employment Survey; Bureau of the Census; and Science Resources Division, National Science Foundation, unpublished tabulations.

Appendix table 3–22.

Scientists and engineers engaged in R&D and per 10,000 labor force population, by country: 1985–90

	Engaged in R&D						Per 10,000 labor force					
	United States	Japan	West Germany	France	United Kingdom	Italy	United States	Japan	West Germany	France	United Kingdom	Italy
	Thousands											
1965	494.2	117.6	61.0	42.8	49.9	NA	64.7	24.6	22.6	20.9	19.6	NA
1966	521.1	128.9	60.0	60.0	NA	NA	66.9	26.4	22.3	29.1	NA	NA
1967	534.4	138.7	64.5	52.4	NA	NA	67.2	27.8	24.4	25.2	NA	NA
1968	549.9	157.6	68.0	54.7	52.8	NA	67.9	31.1	25.9	26.2	20.8	NA
1969	552.7	157.1	74.9	57.2	NA	25.4	66.6	30.8	28.2	27.1	NA	12.2
1970	543.8	172.0	82.5	58.5	NA	27.6	64.1	33.4	30.8	27.3	NA	13.2
1971	523.5	194.3	90.2	60.1	NA	30.9	60.6	37.5	33.5	27.8	NA	14.8
1972	515.0	198.1	96.0	61.2	76.7	32.6	58.0	38.1	35.4	28.1	30.3	15.7
1973	514.6	226.6	101.0	62.7	NA	33.3	56.4	42.5	36.8	28.5	NA	15.9
1974	520.6	238.2	102.5	64.1	NA	34.3	55.6	44.9	37.4	28.8	NA	16.3
1975	527.4	255.2	103.7	65.3	80.5	37.9	55.3	47.9	38.2	29.2	31.1	17.8
1976	535.2	260.2	104.5	67.0	NA	37.9	54.7	48.4	38.7	29.6	NA	17.6
1977	560.6	272.0	111.0	68.0	NA	39.7	55.7	49.9	41.1	29.7	NA	18.2
1978	586.6	273.1	113.9	70.9	87.7	40.8	56.5	49.4	41.9	30.7	33.3	18.6
1979	614.5	281.9	116.9	72.9	NA	46.4	57.7	50.4	42.5	31.4	NA	20.8
1980	651.1	302.6	120.7	74.9	NA	47.0	60.0	53.6	43.2	32.1	NA	20.8
1981	683.2	317.5	124.7	85.5	95.4	52.1	61.9	55.6	44.0	36.3	35.7	22.9
1982	711.8	329.7	NA	90.1	NA	56.7	63.6	57.1	NA	37.9	NA	24.9
1983	751.6	342.2	130.8	92.7	94.0	63.0	66.4	58.1	45.7	39.1	35.3	27.3
1984	797.6	370.0	NA	98.2	NA	62.0	69.2	62.4	NA	41.1	NA	26.6
1985	841.2	381.3	143.6	102.3	97.8	63.8	71.8	63.9	49.7	42.8	35.3	27.1
1986	882.3	405.6	NA	105.0	101.7	67.8	73.8	67.4	NA	43.7	36.6	28.4
1987	910.2	418.3	165.6	109.4	101.4	70.6	74.9	68.8	56.4	45.4	36.2	29.4
1988	927.3	441.9	NA	115.2	102.6	74.8	75.2	71.7	NA	47.6	36.3	30.9
1989	949.3	461.6	176.4	120.7	NA	76.1	75.6	73.6	59.3	49.7	NA	31.4
1990	NA	482.3	NA	NA	NA	NA	NA	75.6	NA	NA	NA	NA

NA = not available

NOTES: Data include all scientists and engineers engaged in R&D on a full-time basis with the following exceptions. Japanese data include persons primarily employed in R&D in the natural sciences and engineering, and the United Kingdom data include only government and industry sectors. The figures for Germany are for the former West Germany only; these data increased in 1979 because of increased coverage of small and medium sized enterprises not surveyed in 1977, and data starting with 1979 were revised in 1988 using improved methodologies. The figures for France increased in 1981 in part because of a re-evaluation of university research efforts.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1992*, Final Report, NSF 92-330 (Washington, DC: NSF, 1992); Organisation for Economic Co-operation and Development; and national sources.

See figure 3-17.

Appendix table 4–1.
GDP and GDP implicit price deflators: 1960–94

	GDP implicit price deflators		GDP	
	Calendar year	Fiscal year	Calendar year	Fiscal year
			Billions of dollars	
1960	0.260	0.261	513.3	505.9
1961	0.263	0.263	531.8	516.9
1962	0.269	0.268	571.6	554.3
1963	0.272	0.272	603.1	585.0
1964	0.277	0.276	648.0	626.5
1965	0.284	0.283	702.7	671.4
1966	0.294	0.291	769.8	738.6
1967	0.303	0.301	814.3	791.3
1968	0.318	0.312	889.3	849.8
1969	0.334	0.328	959.5	925.6
1970	0.352	0.346	1,010.7	985.6
1971	0.371	0.363	1,097.2	1,051.6
1972	0.388	0.382	1,207.0	1,145.8
1973	0.413	0.402	1,349.6	1,278.0
1974	0.449	0.433	1,458.6	1,403.3
1975	0.492	0.476	1,585.9	1,511.0
1976	0.523	0.512	1,768.4	1,685.1
1977	0.559	0.554	1,974.1	1,919.7
1978	0.603	0.596	2,232.7	2,156.4
1979	0.656	0.647	2,488.6	2,431.9
1980	0.717	0.706	2,708.0	2,644.5
1981	0.789	0.778	3,030.6	2,964.7
1982	0.838	0.836	3,149.6	3,124.9
1983	0.872	0.870	3,405.0	3,317.0
1984	0.910	0.909	3,777.2	3,696.7
1985	0.944	0.943	4,038.7	3,970.9
1986	0.969	0.971	4,268.6	4,219.6
1987	1.000	1.000	4,539.9	4,453.3
1988	1.039	1.036	4,900.4	4,810.0
1989	1.085	1.082	5,250.8	5,170.1
1990	1.132	1.127	5,522.2	5,459.5
1991	1.178	1.168	5,677.5	5,626.6
1992	1.209	1.201	5,943.1	5,869.6
1993	1.238	1.230	6,254.2	6,172.3
1994	1.267	1.260	6,593.5	6,506.9

NOTE: Data are as of March 9, 1993.

SOURCES: Bureau of Economic Analysis, *Survey of Current Business* (Washington, DC: Department of Commerce, monthly series); and Office of Management and Budget, unpublished tabulations.

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Appendix table 4–2.
Purchasing power parities and market exchange rates, by selected country: 1970–91

	Purchasing power parities						Market exchange rates	
	Canada	France	Germany	Italy	Japan	United Kingdom	Germany	Japan
	Units of foreign currency per U.S. dollar							
1970	1.11	4.23	2.87	401	241	0.273	3.65	358
1971	1.09	4.28	2.94	408	242	0.284	3.48	347
1972	1.10	4.39	2.96	415	245	0.294	3.19	303
1973	1.13	4.47	2.95	440	260	0.295	2.65	271
1974	1.16	4.60	2.89	484	286	0.311	2.58	292
1975	1.18	4.73	2.79	513	280	0.360	2.45	297
1976	1.21	4.94	2.72	572	284	0.390	2.52	297
1977	1.20	5.04	2.64	635	283	0.417	2.32	268
1978	1.19	5.17	2.56	675	277	0.432	2.00	208
1979	1.20	5.23	2.45	715	261	0.454	1.83	218
1980	1.22	5.35	2.35	786	250	0.497	1.81	226
1981	1.23	5.44	2.24	855	237	0.506	2.25	221
1982	1.26	5.73	2.19	941	226	0.511	2.43	249
1983	1.27	6.07	2.20	1,048	222	0.520	2.55	238
1984	1.27	6.29	2.16	1,129	219	0.525	2.85	238
1985	1.27	6.48	2.15	1,196	217	0.548	2.94	239
1986	1.27	6.68	2.18	1,264	216	0.548	2.17	168
1987	1.29	6.69	2.16	1,300	210	0.559	1.80	145
1988	1.31	6.69	2.12	1,342	204	0.576	1.76	128
1989	1.32	6.66	2.09	1,371	200	0.593	1.88	138
1990	1.31	6.59	2.08	1,415	196	0.608	1.62	145
1991	1.30	6.53	2.09	1,460	193	0.623	1.70	135

NOTE: German data are for the former West Germany only.

SOURCES: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators database; and International Monetary Fund, *International Statistics Yearbook* (Washington, DC: IMF, 1992).

See figure 4–6.

Appendix table 4–3.

U.S. R&D expenditures, by performing sector and source of funds: 1960–93

(page 1 of 2)

[Performing sector]		Federal Govt.	Industry			Industry FFRDCs	Universities and colleges						U&C FFRDCs	Nonprofit institutions				Nonprofit FFRDCs
[Source of funds]	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.	Total	Federal Govt.	Industry	Nonfed. Govt.	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.
	Millions of current dollars																	
1960	13,520	1,723	10,032	5,604	4,428	477	646	405	40	85	64	52	360	259	143	48	68	23
1961	14,320	1,878	10,353	5,685	4,668	555	763	500	40	95	70	58	410	288	153	49	86	73
1962	15,392	2,096	11,038	6,009	5,029	426	904	613	40	106	79	66	470	348	185	54	109	110
1963	17,059	2,279	12,216	6,856	5,360	414	1,081	760	41	118	89	73	530	389	215	55	119	150
1964	18,854	2,838	13,049	7,257	5,792	463	1,275	917	40	132	103	83	629	420	253	55	112	180
1965	20,044	3,093	13,812	7,367	6,445	373	1,474	1,073	41	143	124	93	629	433	247	62	124	230
1966	21,846	3,220	15,193	7,977	7,216	355	1,715	1,261	42	156	148	108	630	533	325	70	138	200
1967	23,146	3,396	15,966	7,946	8,020	419	1,921	1,409	48	164	181	119	673	551	332	74	145	220
1968	24,605	3,494	17,014	8,145	8,869	415	2,149	1,572	55	172	218	132	719	584	352	81	151	230
1969	25,629	3,501	17,844	7,987	9,857	464	2,225	1,600	60	197	223	145	725	630	376	93	161	240
1970	26,134	4,079	17,594	7,306	10,288	473	2,335	1,647	61	219	243	165	737	666	399	95	172	250
1971	26,676	4,228	17,829	7,175	10,654	491	2,500	1,724	70	255	274	177	716	702	420	98	184	210
1972	28,476	4,589	19,004	7,469	11,535	548	2,630	1,795	74	269	305	187	753	732	433	101	198	220
1973	30,718	4,762	20,704	7,600	13,104	545	2,884	1,985	84	295	318	202	817	826	510	105	211	180
1974	32,863	4,911	22,239	7,572	14,667	648	3,022	2,032	95	308	368	219	865	978	622	115	241	200
1975	35,213	5,354	23,460	7,878	15,582	727	3,409	2,288	113	332	417	259	987	1,056	655	125	276	220
1976	39,018	5,769	26,107	8,671	17,436	890	3,729	2,512	123	364	446	285	1,147	1,146	695	135	316	230
1977	42,783	6,012	28,863	9,523	19,340	962	4,067	2,726	139	374	514	314	1,384	1,235	727	150	358	260
1978	48,128	6,810	32,222	10,107	22,115	1,082	4,625	3,059	170	414	623	359	1,717	1,352	780	165	407	320
1979	54,953	7,418	37,062	11,354	25,708	1,164	5,380	3,604	194	476	738	368	1,935	1,624	980	180	464	370
1980	62,610	7,632	43,228	12,752	30,476	1,277	6,077	4,104	236	496	837	403	2,246	1,700	1,000	200	500	450
1981	71,869	8,426	50,425	14,997	35,428	1,385	6,847	4,571	292	546	1,004	435	2,486	1,750	1,000	225	525	550
1982	80,018	9,141	57,166	17,061	40,105	1,484	7,323	4,768	337	616	1,111	491	2,479	1,925	1,150	250	525	500
1983	89,143	10,582	63,683	19,095	44,588	1,585	7,881	4,989	389	626	1,302	576	2,737	2,075	1,250	275	550	600
1984	101,142	11,572	73,061	21,657	51,404	1,739	8,620	5,430	475	690	1,411	614	3,150	2,400	1,500	325	575	600
1985	113,818	12,945	82,376	25,333	57,043	1,863	9,686	6,063	560	752	1,617	694	3,523	2,725	1,700	375	650	700
1986	119,531	13,535	85,556	25,624	59,932	2,267	10,928	6,710	700	915	1,868	734	3,895	2,800	1,700	425	675	550
1987	125,353	13,413	89,804	28,401	61,403	2,351	12,154	7,341	790	1,024	2,168	831	4,206	2,925	1,700	450	775	500
1988	133,742	14,281	95,351	29,579	65,772	2,538	13,466	8,191	872	1,107	2,355	941	4,531	3,075	1,700	500	875	500
1989	140,771	15,121	99,222	28,660	70,562	2,632	15,016	8,991	998	1,234	2,712	1,080	4,730	3,550	2,000	550	1,000	500
1990	146,434	16,002	101,842	27,862	73,980	2,764	16,344	9,636	1,134	1,340	3,017	1,218	4,832	4,000	2,250	600	1,150	650
1991	145,383	15,238	99,524	22,586	76,938	2,722	17,620	10,221	1,216	1,483	3,369	1,333	5,079	4,500	2,600	650	1,250	700
1992	154,500	16,600	105,100	26,100	79,000	2,700	19,050	10,800	1,350	1,650	3,750	1,500	5,300	5,050	2,950	700	1,400	700
1993	160,750	16,600	109,600	28,300	81,300	2,700	20,550	11,400	1,500	1,850	4,150	1,650	5,300	5,300	3,000	750	1,550	700

(continued)

Appendix table 4–3.

U.S. R&D expenditures, by performing sector and source of funds: 1960–93

(page 2 of 2)

[Performing sector]		Federal Govt.	Industry			Industry FFRDCs	Universities and colleges						U&C FFRDCs	Nonprofit institutions				Nonprofit FFRDCs
[Source of funds]	Total U.S.	Federal Govt.	Total	Federal Govt.	Industry	Federal Govt.	Total	Federal Govt.	Industry	Nonfed. Govt.	U&C	Non-profits	Federal Govt.	Total	Federal Govt.	Industry	Non-profits	Federal Govt.
	Millions of constant 1987 dollars																	
1960	51,960	6,602	38,585	21,554	17,031	1,835	2,475	1,552	153	326	245	199	1,379	996	550	185	262	88
1961	54,449	7,141	39,365	21,616	17,749	2,110	2,901	1,901	152	361	266	221	1,559	1,095	582	186	327	278
1962	57,267	7,821	41,033	22,338	18,695	1,584	3,373	2,287	149	396	295	246	1,754	1,294	688	201	405	409
1963	62,717	8,379	44,912	25,206	19,706	1,522	3,974	2,794	151	434	327	268	1,949	1,430	790	202	438	551
1964	68,127	10,283	47,108	26,199	20,910	1,671	4,620	3,322	145	478	373	301	2,279	1,516	913	199	404	650
1965	70,642	10,929	48,634	25,940	22,694	1,313	5,208	3,792	145	505	438	329	2,223	1,525	870	218	437	810
1966	74,501	11,065	51,677	27,133	24,544	1,207	5,893	4,333	144	536	509	371	2,165	1,813	1,105	238	469	680
1967	76,521	11,282	52,693	26,224	26,469	1,383	6,382	4,681	159	545	601	395	2,236	1,818	1,096	244	479	726
1968	77,759	11,199	53,503	25,613	27,890	1,305	6,888	5,038	176	551	699	423	2,304	1,836	1,107	255	475	723
1969	77,087	10,674	53,425	23,913	29,512	1,389	6,784	4,878	183	601	680	442	2,210	1,886	1,126	278	482	719
1970	74,597	11,789	49,983	20,756	29,227	1,344	6,749	4,760	176	633	702	477	2,130	1,892	1,134	270	489	710
1971	72,345	11,647	48,057	19,340	28,717	1,323	6,887	4,749	193	702	755	488	1,972	1,892	1,132	264	496	566
1972	73,714	12,013	48,979	19,250	29,729	1,412	6,885	4,699	194	704	798	490	1,971	1,887	1,116	260	510	567
1973	74,938	11,846	50,131	18,402	31,729	1,320	7,174	4,938	209	734	791	502	2,032	2,000	1,235	254	511	436
1974	73,916	11,342	49,530	16,864	32,666	1,443	6,979	4,693	219	711	850	506	1,998	2,178	1,385	256	537	445
1975	72,237	11,248	47,683	16,012	31,671	1,478	7,162	4,807	237	697	876	544	2,074	2,146	1,331	254	561	447
1976	75,041	11,268	49,918	16,579	33,338	1,702	7,283	4,906	240	711	871	557	2,240	2,191	1,329	258	604	440
1977	76,720	10,852	51,633	17,036	34,597	1,721	7,341	4,921	251	675	928	567	2,498	2,209	1,301	268	640	465
1978	80,070	11,426	53,436	16,761	36,675	1,794	7,760	5,133	285	695	1,045	602	2,881	2,242	1,294	274	675	531
1979	84,082	11,465	56,497	17,308	39,189	1,774	8,315	5,570	300	736	1,141	569	2,991	2,476	1,494	274	707	564
1980	87,669	10,810	60,290	17,785	42,505	1,781	8,608	5,813	334	703	1,186	571	3,181	2,371	1,395	279	697	628
1981	91,407	10,830	63,910	19,008	44,902	1,755	8,801	5,875	375	702	1,290	559	3,195	2,218	1,267	285	665	697
1982	95,541	10,934	68,217	20,359	47,858	1,771	8,760	5,703	403	737	1,329	587	2,965	2,297	1,372	298	626	597
1983	102,284	12,163	73,031	21,898	51,133	1,818	9,059	5,734	447	720	1,497	662	3,146	2,380	1,433	315	631	688
1984	111,173	12,730	80,287	23,799	56,488	1,911	9,483	5,974	523	759	1,552	675	3,465	2,637	1,648	357	632	659
1985	120,599	13,727	87,263	26,836	60,427	1,974	10,271	6,429	594	797	1,715	736	3,736	2,887	1,801	397	689	742
1986	123,295	13,939	88,293	26,444	61,849	2,340	11,254	6,910	721	942	1,924	756	4,011	2,890	1,754	439	697	568
1987	125,353	13,413	89,804	28,401	61,403	2,351	12,154	7,341	790	1,024	2,168	831	4,206	2,925	1,700	450	775	500
1988	128,812	13,785	91,772	28,469	63,303	2,443	12,998	7,906	842	1,069	2,273	908	4,374	2,960	1,636	481	842	481
1989	129,832	13,975	91,449	26,415	65,034	2,426	13,878	8,310	922	1,140	2,506	998	4,372	3,272	1,843	507	922	461
1990	129,504	14,199	89,966	24,613	65,353	2,442	14,502	8,550	1,006	1,189	2,677	1,081	4,287	3,534	1,988	530	1,016	574
1991	123,691	13,046	84,486	19,173	65,312	2,311	15,086	8,751	1,041	1,270	2,884	1,141	4,348	3,820	2,207	552	1,061	594
1992	128,017	13,822	86,931	21,588	65,343	2,233	15,862	8,993	1,124	1,374	3,122	1,249	4,413	4,177	2,440	579	1,158	579
1993	130,070	13,496	88,530	22,859	65,670	2,181	16,707	9,268	1,220	1,504	3,374	1,341	4,309	4,281	2,423	606	1,252	565

FFRDC = federally funded research and development center; U&C = universities and colleges

NOTES: Data are preliminary for 1992 and estimated for 1993. Historical series are based on annual surveys of R&D performers except for the nonprofit sector, for which data generally are estimated. Total funds used by the Federal government are from federal sources. *Industry* federally funded research and development centers (FFRDCs) are assumed to be 100-percent federally funded. Industry FFRDC data for 1960–63 are federal obligations as reported by funding agencies; data for 1964–93 are expenditures as reported by industry FFRDC performers. *University and college* (U&C) FFRDCs are administered by individual universities and by university consortia. In 1991, U&C FFRDCs were 99-percent federally funded. *Nonprofit* FFRDCs are assumed to be 100-percent federally funded; these data are federal obligations as reported by funding agencies and were rounded to two significant digits for 1960–79, and the nearest $50 million for 1964–93. See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1992*, NSF 92-330 (Washington, DC: NSF, 1992); and unpublished tabulations.

See figure 4–21 and text table 4–1

Appendix table 4–4.
National expenditures for total R&D, by source of funds and performer: 1970–93

		Source of funds				Performer				
	Total	Federal Government	Industry	Universities & colleges[1]	Other nonprofits	Federal Government	Industry	Universities & colleges	U&C FFRDCs[2]	Other nonprofits
					Millions of current dollars					
1970	26,134	14,891	10,444	462	337	4,079	18,067	2,335	737	916
1971	26,676	14,964	10,822	529	361	4,228	18,320	2,500	716	912
1972	28,476	15,807	11,710	574	385	4,589	19,552	2,630	753	952
1973	30,718	16,399	13,293	613	413	4,762	21,249	2,884	817	1,006
1974	32,863	16,850	14,877	676	460	4,911	22,887	3,022	865	1,178
1975	35,213	18,109	15,820	749	535	5,354	24,187	3,409	987	1,276
1976	39,018	19,914	17,694	809	601	5,769	26,997	3,729	1,147	1,376
1977	42,783	21,594	19,629	888	672	6,012	29,825	4,067	1,384	1,495
1978	48,128	23,875	22,450	1,037	766	6,810	33,304	4,625	1,717	1,672
1979	54,953	26,825	26,082	1,214	832	7,418	38,226	5,380	1,935	1,994
1980	62,610	29,461	30,912	1,334	903	7,632	44,505	6,077	2,246	2,150
1981	71,869	33,415	35,945	1,549	960	8,426	51,810	6,847	2,486	2,300
1982	80,018	36,583	40,692	1,727	1,016	9,141	58,650	7,323	2,479	2,425
1983	89,143	40,838	45,252	1,927	1,126	10,582	65,268	7,881	2,737	2,675
1984	101,142	45,648	52,204	2,101	1,189	11,572	74,800	8,620	3,150	3,000
1985	113,818	52,127	57,978	2,369	1,344	12,945	84,239	9,686	3,523	3,425
1986	119,531	54,281	61,057	2,784	1,409	13,535	87,823	10,928	3,895	3,350
1987	125,353	57,912	62,643	3,192	1,606	13,413	92,155	12,154	4,206	3,425
1988	133,742	61,320	67,144	3,462	1,816	14,281	97,889	13,466	4,531	3,575
1989	140,771	62,634	72,110	3,947	2,080	15,121	101,854	15,016	4,730	4,050
1990	146,434	63,996	75,714	4,356	2,368	16,002	104,606	16,344	4,832	4,650
1991	145,383	59,146	78,804	4,850	2,583	15,238	102,246	17,620	5,079	5,200
1992	154,500	65,150	81,050	5,400	2,900	16,600	107,800	19,050	5,300	5,750
1993	160,750	68,000	83,550	6,000	3,200	16,600	112,300	20,550	5,300	6,000
					Millions of constant 1987 dollars[3]					
1970	74,597	42,622	29,673	1,335	966	11,789	51,327	6,749	2,130	2,602
1971	72,345	40,730	29,174	1,457	984	11,647	49,380	6,887	1,972	2,458
1972	73,714	41,029	30,183	1,503	1,000	12,013	50,392	6,885	1,971	2,454
1973	74,938	40,208	32,192	1,525	1,013	11,846	51,450	7,174	2,032	2,436
1974	73,916	38,170	33,141	1,561	1,043	11,342	50,973	6,979	1,998	2,624
1975	72,237	37,396	32,162	1,574	1,105	11,248	49,161	7,162	2,074	2,593
1976	75,041	38,464	33,837	1,580	1,161	11,268	51,620	7,283	2,240	2,631
1977	76,720	38,793	35,117	1,603	1,207	10,852	53,354	7,341	2,498	2,674
1978	80,070	39,819	37,234	1,740	1,277	11,426	55,231	7,760	2,881	2,773
1979	84,082	41,167	39,763	1,876	1,276	11,465	58,271	8,315	2,991	3,040
1980	87,669	41,393	43,118	1,890	1,268	10,810	62,071	8,608	3,181	2,999
1981	91,407	42,629	45,563	1,991	1,225	10,830	65,665	8,801	3,195	2,915
1982	95,541	43,702	48,559	2,066	1,214	10,934	69,988	8,760	2,965	2,894
1983	102,284	46,881	51,896	2,215	1,293	12,163	74,849	9,059	3,146	3,068
1984	111,173	50,187	57,368	2,311	1,307	12,730	82,198	9,483	3,465	3,297
1985	120,599	55,245	61,418	2,512	1,425	13,727	89,236	10,271	3,736	3,628
1986	123,295	55,966	63,009	2,867	1,453	13,939	90,633	11,254	4,011	3,457
1987	125,353	57,912	62,643	3,192	1,606	13,413	92,155	12,154	4,206	3,425
1988	128,812	59,094	64,626	3,342	1,750	13,785	94,215	12,998	4,374	3,441
1989	129,832	57,801	66,463	3,648	1,920	13,975	93,875	13,878	4,372	3,733
1990	129,504	56,653	66,890	3,865	2,097	14,199	92,408	14,502	4,287	4,108
1991	123,691	50,431	66,905	4,152	2,202	13,046	86,796	15,086	4,348	4,414
1992	128,017	54,068	67,046	4,496	2,407	13,822	89,165	15,862	4,413	4,756
1993	130,070	55,102	67,496	4,878	2,593	13,496	90,711	16,707	4,309	4,847

FFRDC = federally funded research and development center; U&C = universities and colleges

NOTES: Data are preliminary for 1992 and estimated for 1993. Data are based on annual reports by performers except for the nonprofit sector, for which data generally are estimated. Expenditures for FFRDCs administered by industry and nonprofit institutions are included in the totals of the respective sectors.

[1] Includes state and local government funds to the university and college sector.

[2] U&C FFRDCs are administered by individual universities and colleges and by university consortia.

[3] See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1992*, NSF 92-330 (Washington, DC: NSF, 1992); and unpublished tabulations.

See figures 4–1 and 4–2.

Appendix table 4–5.

National expenditures for basic research, by source of funds and performer: 1970–93

		Source of funds				Performer				
	Total	Federal Government	Industry[1]	Universities & colleges[2]	Other nonprofits	Federal Government	Industry	Universities & colleges	U&C FFRDCs[3]	Other nonprofits
	Millions of current dollars									
1970	3,531	2,471	528	350	182	559	602	1,796	269	305
1971	3,652	2,509	547	400	196	566	590	1,914	260	322
1972	3,801	2,605	563	415	218	597	593	2,022	244	345
1973	3,945	2,708	605	408	224	608	631	2,053	296	357
1974	4,343	3,017	650	431	245	696	699	2,153	390	405
1975	4,738	3,270	705	477	286	734	730	2,410	439	425
1976	5,130	3,589	769	475	297	786	819	2,549	512	464
1977	5,735	4,021	850	527	337	914	911	2,800	600	510
1978	6,649	4,702	964	605	378	1,029	1,035	3,133	867	585
1979	7,570	5,350	1,092	716	412	1,089	1,158	3,628	1,015	680
1980	8,433	5,909	1,271	797	456	1,182	1,325	4,042	1,124	760
1981	9,595	6,619	1,589	907	480	1,302	1,614	4,593	1,261	825
1982	10,429	7,099	1,833	998	499	1,465	1,904	4,878	1,317	865
1983	11,633	7,771	2,121	1,171	570	1,690	2,223	5,303	1,472	945
1984	12,906	8,491	2,565	1,254	596	1,861	2,608	5,732	1,675	1,030
1985	14,192	9,176	2,885	1,447	684	1,923	2,862	6,553	1,749	1,105
1986	16,585	9,993	4,132	1,733	727	2,019	4,047	7,490	1,859	1,170
1987	17,993	10,870	4,289	2,003	831	2,046	4,323	8,392	2,012	1,220
1988	18,775	11,604	4,134	2,113	924	2,050	4,280	8,893	2,222	1,330
1989	20,648	12,967	4,269	2,365	1,047	2,371	4,646	9,801	2,330	1,500
1990	22,099	13,705	4,586	2,616	1,192	2,366	4,909	10,681	2,403	1,740
1991	22,829	14,351	4,257	2,919	1,302	2,446	4,373	11,538	2,572	1,900
1992	24,380	15,350	4,410	3,180	1,440	2,700	4,500	12,400	2,700	2,080
1993	26,220	16,450	4,640	3,540	1,590	2,900	4,700	13,500	2,850	2,270
	Millions of constant 1987 dollars[4]									
1970	10,161	7,125	1,502	1,012	522	1,616	1,710	5,191	777	866
1971	10,006	6,892	1,477	1,102	535	1,559	1,590	5,273	716	868
1972	9,912	6,805	1,453	1,086	567	1,563	1,528	5,293	639	889
1973	9,748	6,713	1,469	1,015	551	1,512	1,528	5,107	736	864
1974	9,939	6,934	1,453	995	557	1,607	1,557	4,972	901	902
1975	9,875	6,842	1,438	1,002	593	1,542	1,484	5,063	922	864
1976	9,967	6,991	1,473	928	575	1,535	1,566	4,979	1,000	887
1977	10,329	7,250	1,522	951	606	1,650	1,630	5,054	1,083	912
1978	11,124	7,878	1,601	1,015	631	1,727	1,716	5,257	1,455	970
1979	11,661	8,255	1,667	1,107	633	1,683	1,765	5,607	1,569	1,037
1980	11,899	8,354	1,776	1,129	641	1,674	1,848	5,725	1,592	1,060
1981	12,289	8,493	2,017	1,166	613	1,674	2,046	5,904	1,621	1,046
1982	12,467	8,489	2,188	1,194	596	1,752	2,272	5,835	1,575	1,032
1983	13,363	8,929	2,433	1,346	655	1,943	2,549	6,095	1,692	1,084
1984	14,194	9,340	2,819	1,380	655	2,047	2,866	6,306	1,843	1,132
1985	15,045	9,729	3,057	1,534	725	2,039	3,032	6,949	1,855	1,171
1986	17,091	10,294	4,263	1,785	749	2,079	4,176	7,714	1,915	1,207
1987	17,993	10,870	4,289	2,003	831	2,046	4,323	8,392	2,012	1,220
1988	18,107	11,196	3,980	2,040	891	1,979	4,119	8,584	2,145	1,280
1989	19,067	11,979	3,936	2,186	967	2,191	4,282	9,058	2,153	1,382
1990	19,583	12,152	4,054	2,321	1,056	2,099	4,337	9,477	2,132	1,537
1991	19,500	12,270	3,619	2,499	1,111	2,094	3,712	9,878	2,202	1,613
1992	20,263	12,768	3,652	2,648	1,196	2,248	3,722	10,325	2,248	1,720
1993	21,280	13,360	3,753	2,878	1,289	2,358	3,796	10,976	2,317	1,834

FFRDC = federally funded research and development center; U&C = universities and colleges

NOTES: Data are preliminary for 1992 and estimated for 1993. Data are based on annual reports by performers except for the nonprofit sector, for which data generally are estimated. Expenditures for FFRDCs administered by industry and nonprofit institutions are included in the totals of the respective sector.

[1] The imputation procedure for industry funding of its basic research changed for 1986 and after. These data may not be comparable to data for 1985 and earlier.

[2] Includes state and local government funds to the university and college sector.

[3] U&C FFRDCs are administered by individual universities and colleges and by university consortia.

[4] See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1992*, NSF 92-330 (Washington, DC: NSF, 1992); and unpublished tabulations.

See figures 4–2 and 4–3.

Appendix table 4-6.
National expenditures for applied research, by source of funds and performer: 1970–93

		Source of funds				Performer				
	Total	Federal Government	Industry[1]	Universities & colleges[2]	Other nonprofits	Federal Government	Industry	Universities & colleges	U&C FFRDCs[3]	Other nonprofits
					Millions of current dollars					
1970	5,738	3,097	2,427	99	115	1,345	3,427	427	216	323
1971	5,759	3,028	2,494	115	122	1,322	3,415	474	210	338
1972	6,011	3,131	2,615	140	125	1,387	3,514	524	221	365
1973	6,598	3,395	2,891	172	140	1,480	3,825	713	227	353
1974	7,189	3,495	3,332	203	159	1,574	4,288	736	178	413
1975	7,802	3,878	3,517	225	182	1,730	4,570	851	203	448
1976	8,954	4,442	4,003	282	227	2,093	5,112	1,016	235	498
1977	9,570	4,611	4,410	303	246	2,044	5,636	1,067	290	533
1978	10,584	4,969	4,981	354	280	2,191	6,300	1,184	319	590
1979	11,982	5,478	5,796	413	295	2,392	7,225	1,313	342	710
1980	13,619	6,168	6,693	444	314	2,484	8,450	1,536	424	725
1981	16,366	6,957	8,535	534	340	2,732	10,699	1,731	424	780
1982	18,155	7,618	9,566	608	363	2,729	12,323	1,858	430	815
1983	20,266	8,752	10,507	621	386	3,020	13,927	1,988	456	875
1984	22,383	9,458	11,810	700	415	2,903	15,765	2,254	541	920
1985	25,334	10,910	13,217	756	451	3,133	18,255	2,420	591	935
1986	27,075	10,316	15,437	856	466	3,141	19,760	2,629	565	980
1987	27,685	10,645	15,542	966	532	3,392	19,813	2,912	538	1,030
1988	29,076	10,642	16,706	1,107	621	3,288	20,595	3,519	534	1,140
1989	31,984	12,018	17,943	1,306	717	3,611	22,388	4,080	605	1,300
1990	33,667	12,524	18,897	1,435	811	3,587	23,628	4,363	629	1,460
1991	35,350	13,086	19,785	1,591	888	4,093	24,084	4,570	933	1,670
1992	37,610	14,250	20,510	1,840	1,010	4,450	25,400	4,920	1,000	1,840
1993	39,680	15,450	21,070	2,040	1,120	4,900	26,500	5,360	1,000	1,920
					Millions of constant 1987 dollars[4]					
1970	16,399	8,888	6,896	286	329	3,887	9,736	1,234	624	918
1971	15,642	8,270	6,724	317	332	3,642	9,205	1,306	579	911
1972	15,579	8,148	6,740	366	324	3,631	9,057	1,372	579	941
1973	16,136	8,364	7,002	428	343	3,682	9,262	1,774	565	855
1974	16,216	7,964	7,423	469	360	3,635	9,550	1,700	411	920
1975	16,048	8,049	7,151	473	375	3,634	9,289	1,788	426	911
1976	17,258	8,613	7,656	551	438	4,088	9,774	1,984	459	952
1977	17,175	8,296	7,890	547	442	3,690	10,082	1,926	523	953
1978	17,624	8,302	8,261	594	467	3,676	10,448	1,987	535	978
1979	18,351	8,424	8,837	638	452	3,697	11,014	2,029	529	1,082
1980	19,091	8,685	9,336	629	441	3,518	11,785	2,176	601	1,011
1981	20,830	8,891	10,819	686	434	3,512	13,560	2,225	545	989
1982	21,679	9,102	11,416	727	434	3,264	14,705	2,222	514	973
1983	23,255	10,049	12,050	714	443	3,471	15,971	2,285	524	1,003
1984	24,604	10,399	12,978	770	456	3,194	17,324	2,480	595	1,011
1985	26,844	11,563	14,001	802	478	3,322	19,338	2,566	627	990
1986	27,928	10,635	15,930	882	480	3,235	20,392	2,708	582	1,011
1987	27,685	10,645	15,542	966	532	3,392	19,813	2,912	538	1,030
1988	28,005	10,258	16,080	1,069	599	3,174	19,822	3,397	515	1,097
1989	29,500	11,093	16,538	1,207	662	3,337	20,634	3,771	559	1,198
1990	29,775	11,089	16,695	1,273	718	3,183	20,873	3,871	558	1,290
1991	30,078	11,161	16,798	1,362	757	3,504	20,445	3,913	799	1,418
1992	31,165	11,828	16,967	1,532	838	3,705	21,009	4,097	833	1,522
1993	32,111	12,523	17,022	1,659	908	3,984	21,405	4,358	813	1,551

FFRDC = federally funded research and development center; U&C = universities and colleges

NOTES: Data are preliminary for 1992 and estimated for 1993. Data are based on annual reports by performers except for the nonprofit sector, for which data are estimated. Since 1978, the applied research/development split for the academic sector has been estimated. Expenditures for FFRDCs administered by industry and nonprofit institutions are included in the totals of the respective sector.

[1] The imputation procedure for industry funding of its applied research changed for 1986 and after. These data may not be comparable to data for 1985 and earlier.

[2] Includes state and local government funds to the university and college sector.

[3] U&C FFRDCs are administered by individual universities and colleges and by university consortia.

[4] See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1992*, NSF 92-330 (Washington, DC: NSF, 1992); and unpublished tabulations.

See figures 4-2 and 4-3.

Appendix table 4–7.

National expenditures for development, by source of funds and performer: 1970–93

		Source of funds				Performer				
	Total	Federal Government	Industry[1]	Universities & colleges[2]	Other nonprofits	Federal Government	Industry	Universities & colleges	U&C FFRDCs[3]	Other nonprofits
					Millions of current dollars					
1970	16,865	9,323	7,489	13	40	2,175	14,038	112	252	288
1971	17,265	9,427	7,781	14	43	2,340	14,315	112	246	252
1972	18,664	10,071	8,532	19	42	2,605	15,445	84	288	242
1973	20,175	10,296	9,797	33	49	2,674	16,793	118	294	296
1974	21,331	10,338	10,895	42	56	2,641	17,900	133	297	360
1975	22,673	10,961	11,598	47	67	2,890	18,887	148	345	403
1976	24,934	11,883	12,922	52	77	2,890	21,066	164	400	414
1977	27,478	12,962	14,369	58	89	3,054	23,278	200	494	452
1978	30,895	14,204	16,505	78	108	3,590	25,969	308	531	497
1979	35,401	15,997	19,194	85	125	3,937	29,843	439	578	604
1980	40,558	17,384	22,948	93	133	3,966	34,730	499	698	665
1981	45,908	19,839	25,821	108	140	4,392	39,497	523	801	695
1982	51,434	21,866	29,293	121	154	4,947	44,423	587	732	745
1983	57,244	24,315	32,624	135	170	5,872	49,118	590	809	855
1984	65,853	27,699	37,829	147	178	6,808	56,427	634	934	1,050
1985	74,292	32,041	41,876	166	209	7,889	63,122	713	1,183	1,385
1986	75,871	33,972	41,488	195	216	8,375	64,016	809	1,471	1,200
1987	79,675	36,397	42,812	223	243	7,975	68,019	850	1,656	1,175
1988	85,891	39,074	46,304	242	271	8,943	73,014	1,054	1,775	1,105
1989	88,139	37,649	49,898	276	316	9,139	74,820	1,135	1,795	1,250
1990	90,668	37,767	52,231	305	365	10,049	76,069	1,300	1,800	1,450
1991	87,204	31,709	54,762	340	393	8,699	73,789	1,512	1,574	1,630
1992	92,510	35,550	56,130	380	450	9,450	77,900	1,730	1,600	1,830
1993	94,850	36,100	57,840	420	490	8,800	81,100	1,690	1,450	1,810
					Millions of constant 1987 dollars[4]					
1970	48,037	26,609	21,276	38	114	6,286	39,881	324	728	818
1971	46,697	25,568	20,973	39	116	6,446	38,585	309	678	679
1972	48,224	26,076	21,990	50	109	6,819	39,807	220	754	624
1973	49,054	25,131	23,722	82	119	6,652	40,661	294	731	717
1974	47,761	23,272	24,266	97	126	6,099	39,866	307	686	802
1975	46,314	22,505	23,574	99	137	6,071	38,388	311	725	819
1976	47,817	22,860	24,708	102	148	5,645	40,279	320	781	792
1977	49,216	23,247	25,705	105	159	5,513	41,642	361	892	809
1978	51,322	23,640	27,372	131	180	6,023	43,066	517	891	824
1979	54,070	24,488	29,259	131	191	6,085	45,492	679	893	921
1980	56,678	24,355	32,006	132	186	5,618	48,438	707	989	927
1981	58,287	25,244	32,727	139	178	5,645	50,060	672	1,030	881
1982	61,395	26,110	34,956	145	184	5,917	53,011	702	876	889
1983	65,666	27,903	37,413	155	195	6,749	56,328	678	930	981
1984	72,376	30,448	41,570	162	196	7,490	62,008	697	1,028	1,154
1985	78,710	33,952	44,360	176	221	8,366	66,867	756	1,255	1,467
1986	78,276	35,037	42,815	201	223	8,625	66,064	833	1,515	1,238
1987	79,675	36,397	42,812	223	243	7,975	68,019	850	1,656	1,175
1988	82,700	37,639	44,566	234	261	8,632	70,273	1,017	1,713	1,064
1989	81,265	34,729	45,989	255	291	8,446	68,959	1,049	1,659	1,152
1990	80,147	33,413	46,141	271	323	8,917	67,199	1,154	1,597	1,281
1991	74,113	27,000	46,488	291	334	7,448	62,639	1,295	1,348	1,384
1992	76,588	29,472	46,427	316	373	7,868	64,433	1,440	1,332	1,514
1993	76,678	29,219	46,721	341	396	7,154	65,509	1,374	1,179	1,462

FFRDC = federally funded research and development center; U&C = universities and colleges

NOTES: Data are preliminary for 1992 and estimated for 1993. Data are based on annual reports by performers except for the nonprofit sector, for which data are estimated. Since 1978, the applied research/development split for the academic sector has been estimated. Expenditures for FFRDCs administered by industry and nonprofit institutions are included in the totals of the respective sector.

[1] The imputation procedure for industry funding of its development changed for 1986 and after. These data may not be comparable to data for 1985 and earlier.

[2] Includes state and local government funds to the university and college sector.

[3] U&C FFRDCs are administered by individual universities and colleges and by university consortia.

[4] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *National Patterns of R&D Resources: 1992*, NSF 92-330 (Washington, DC: NSF, 1992); and unpublished tabulations.

See figures 4–2 and 4–3.

Appendix table 4–8.

Geographic distribution of U.S. R&D expenditures, by performer and source of funds: 1991

(page 1 of 2)

		Federal Govt.	Industry			Universities & colleges						U&C FFRDCs	Non-profits
				Sources			Sources						
Geographic area	United States	Total used[1]	Total used	Federal Govt.	Industry[2]	Total used[3]	Federal Govt.	Nonfed. govt.	Industry	U&C	All other	Total used[4]	Total used[5]
						Millions of dollars							
Total, U.S	$145,385	$15,238	$102,246	$25,308	$76,938	17,622	$10,221	$1,483	$1,216	$3,369	$1,333	$5,079	5,200
New England	11,625	658	8,408	2,013	6,395	1,507	1,029	34	124	180	140	389	664
Connecticut	1,913	47	1,535	504	1,031	317	197	6	16	70	28	0	15
Maine	NA	14	0-284	0-18	0-266	27	10	2	5	10	1	0	16
Massachusetts	8,561	278	6,335	1,480	4,855	949	679	13	91	66	100	389	610
New Hampshire	NA	88	102-120	0-18	102	79	53	4	4	10	8	0	0
Rhode Island	485	226	152	11	141	88	60	5	4	18	2	0	18
Vermont	NA	5	0-284	0-18	0-266	47	31	3	4	6	2	0	5
Middle Atlantic	26,752	1,002	22,340	4,473	17,867	2,689	1,634	147	205	438	265	402	320
New Jersey	8,768	513	7,810	855	6,955	342	148	43	19	107	25	91	12
New York	10,363	174	8,268	1,558	6,710	1,467	934	77	85	191	180	284	170
Pennsylvania	7,621	315	6,262	2,060	4,202	879	553	27	100	140	60	27	138
South Atlantic	19,384	7,001	8,593	2,520	6,073	3,205	1,907	310	241	603	145	51	535
Delaware	NA	9	863-995	D	D	45	20	4	5	13	3	0	3
D.C.	1,737	1,433	40	16	24	118	87	0	7	13	11	0	145
Florida	3,700	658	2,599	934	1,665	438	221	37	36	116	29	0	5
Georgia	1,479	121	868	89	779	484	238	43	40	150	13	0	6
Maryland	5,864	3,432	1,203	666	537	1,078	785	82	40	140	32	0	151
North Carolina	1,965	151	1,285	4	1,281	502	304	72	55	52	19	0	27
South Carolina	595	14	419	D	D	151	54	17	16	54	10	0	10
Virginia	2,771	1,107	1,115	679	436	338	179	53	31	52	23	29	182
West Virginia	NA	76	69-201	D	69	51	20	2	11	13	4	22	5
Southeast	3,257	1,044	1,453	637	816	680	360	86	52	137	45	10	70
Alabama	1,503	701	521	221	300	245	125	26	20	52	21	0	36
Kentucky	317	62	154	D	D	98	38	6	11	38	5	0	2
Mississippi	299	157	41	D	D	97	49	21	9	12	6	0	4
Tennessee	1,139	124	737	D	D	240	147	33	12	35	13	10	28
Southwest	7,894	525	5,425	1,418	4,007	1,663	712	229	111	419	192	2	280
Arkansas	198	35	106	D	D	55	20	14	5	13	3	0	2
Louisiana	457	43	172	16	156	240	99	62	16	48	15	0	2
Oklahoma	604	41	392	2	390	153	43	14	9	74	13	0	18
Texas	6,635	405	4,755	D	D	1,216	551	139	83	283	160	2	257
Great Lakes	25,163	973	20,997	1,307	19,690	2,457	1,318	230	176	524	209	574	163
Illinois	6,417	68	5,027	190	4,837	702	362	53	50	181	57	574	47
Indiana	2,347	92	1,988	226	1,762	262	144	20	20	61	17	0	4
Michigan	8,851	92	8,116	89	8,027	601	310	40	50	155	46	0	42
Ohio	5,975	689	4,726	778	3,948	504	285	53	38	74	54	0	57
Wisconsin	1,573	32	1,140	24	1,116	388	218	64	19	53	34	0	13

(continued)

Appendix table 4–8.
Geographic distribution of U.S. R&D expenditures, by performer and source of funds: 1991
(page 2 of 2)

		Federal Govt.	Industry			Universities & colleges						U&C FFRDCs	Non-profits
				Sources			Sources						
Geographic area	United States	Total used[1]	Total used	Federal Govt.	Industry[2]	Total used[3]	Federal Govt.	Nonfed. govt.	Industry	U&C	All other	Total used[4]	Total used[5]
	Millions of dollars												
Plains	5,807	206	4,298	804	3,494	1,191	567	179	84	282	80	26	86
Iowa	777	27	461	D	D	259	124	34	14	74	13	26	3
Kansas	NA	12	0-1,963	D	D	124	44	29	7	40	4	0	5
Minnesota	2,228	41	1,810	150	1,660	332	165	54	19	61	33	0	46
Missouri	NA	71	0-1,963	D	D	306	165	19	30	67	24	0	22
Nebraska	211	22	59	7	52	124	41	36	10	33	5	0	6
North Dakota	NA	24	0-1,963	D	D	31	21	1	2	5	1	0	1
South Dakota	32	9	5	0	5	16	7	7	0	2	1	0	2
Mountain	8,550	1,085	5,185	2,156	3,029	1,080	629	74	77	243	57	1,053	147
Arizona	1,399	132	944	199	745	284	132	8	20	109	16	27	11
Colorado	NA	275	1,751-2,593	0-842	1,751	262	186	13	18	25	20	78	106
Idaho	NA	37	0-985	0-842	0-143	42	16	9	5	12	0	0	1
Montana	NA	26	0-985	0-842	0-143	38	14	9	4	11	0	0	1
Nevada	261	109	83	63	20	67	38	3	5	20	1	0	3
New Mexico	2,582	393	1,064	1,001	63	163	93	15	16	27	12	948	15
Utah	665	103	356	51	305	202	138	17	7	34	6	0	4
Wyoming	41	9	2	0	2	23	13	2	2	6	0	0	7
Pacific	33,118	2,168	24,872	9,739	15,133	2,812	1,873	150	123	486	179	2,563	703
Alaska	146	59	18	D	D	67	34	2	2	28	1	0	2
California	28,337	1,885	21,279	8,911	12,368	2,137	1,432	84	86	387	148	2,563	473
Hawaii	145	45	11	D	D	78	45	27	1	3	2	0	11
Oregon	600	47	349	21	321	179	109	26	7	21	16	0	24
Washington	3,890	133	3,215	D	D	350	253	11	28	45	12	0	193
Other/unknown	3,835	577	675	241	434	341	192	44	24	60	21	8	2,234

D = withheld to avoid disclosing operations of individual companies; NA = not available; FFRDC = federally funded research and development center; U&C = universities and colleges

[1] Total funds used by the Federal Government are from federal sources.

[2] Industry R&D expenditures include all nonfederal sources of funds. For some states, industry sector data fall within the range specified, but have been withheld by the Census Bureau to avoid disclosing individual company operations. Industry performance total for Arkansas, California, Colorado, Florida, Idaho, Kansas, Louisiana, Maine, Massachusetts, Mississippi, Missouri, Montana, North Dakota, Oregon, and Pennsylvania are derived from data with an imputation rate of 50 percent or more.

[3] For universities and colleges, funds distributed by state and region are for doctorate-granting institutions only.

[4] Includes R&D expenditures of university-associated FFRDCs, of which 99 percent were from federal sources.

[5] For the nonprofit sector, funds distributed by state and region include only federal obligations to organizations in this sector. Estimated nonfederal support to the nonprofit sector is included in "other/unknown."

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See text table 4–2.

Appendix table 4–9.
R&D performance, gross state product, and R&D/GSP ratio, by state: 1991

	Total R&D	GSP[3]	R&D/GSP
	Millions of dollars		Percent
Alabama	1,503	75,774	2.0
Alaska	146	22,254	0.7
Arizona	1,399	70,860	2.0
Arkansas	198	41,650	0.5
California	28,337	765,038	3.7
Colorado[1]	2,473	74,952	3.3
Connecticut	1,913	92,773	2.1
Delaware[1]	949	16,500	5.8
District of Columbia	1,737	43,654	4.0
Florida	3,700	249,367	1.5
Georgia	1,479	142,893	1.0
Hawaii	145	30,622	0.5
Idaho[2]	79-1,064	18,516	NA
Illinois	6,417	278,488	2.3
Indiana	2,347	113,883	2.1
Iowa	777	57,223	1.4
Kansas[2]	141-2,104	54,554	NA
Kentucky	317	73,012	0.4
Louisiana	457	88,562	0.5
Maine[2]	57-341	24,546	NA
Maryland	5,864	106,676	5.5
Massachusetts	8,561	147,893	5.8
Michigan	8,851	190,166	4.7
Minnesota	2,228	101,939	2.2
Mississippi	299	41,725	0.7
Missouri[2]	399-2,362	106,919	NA
Montana[2]	66-1,051	14,428	NA
Nebraska	211	35,009	0.6
Nevada	261	33,200	0.8
New Hampshire[1]	270	24,935	1.1
New Jersey	8,768	216,408	4.1
New Mexico	2,582	28,157	9.2
New York	10,363	467,342	2.2
North Carolina	1,965	141,271	1.4
North Dakota[2]	56-2,019	13,465	NA
Ohio	5,975	226,078	2.6
Oklahoma	604	57,569	1.0
Oregon	600	59,424	1.0
Pennsylvania	7,621	247,019	3.1
Rhode Island	485	19,076	2.5
South Carolina	595	67,447	0.9
South Dakota	32	12,746	0.3
Tennessee	1,139	102,473	1.1
Texas	6,635	392,197	1.7
Utah	665	32,142	2.1
Vermont[2]	56-340	12,141	2.8
Virginia	2,771	147,233	1.9
Washington	3,890	112,106	3.5
West Virginia[1]	223	31,671	0.7
Wisconsin	1,573	102,764	1.5
Wyoming	41	12,401	0.3

NA = not available

[1] Total in-state R&D performance of all sectors estimated from range reported in appendix table 4-8.

[2] R&D performance range too wide for point estimation.

[3] Gross state product data are available from the Bureau of Economic Analysis (BEA) through 1989. GSP data for 1991 are estimated here based on changes in employee compensation and proprietors' income between 1989 and 1991, as reported by BEA.

SOURCE: Science Resources Studies Division, National Science Foundation, unpublished tabulations.

See figure 4–4.

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Appendix table 4–10.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1980–94

(page 1 of 6)

Agency	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
	Millions of current dollars														
	Total R&D														
Total, all agencies	29,830	33,104	36,433	38,712	42,225	48,360	51,412	55,255	56,935	61,406	63,667	61,295	67,121	71,546	70,363
Dept. of Agriculture	688	774	797	848	866	943	929	948	1,017	1,038	1,108	1,237	1,327	1,344	1,386
Dept. of Commerce	343	328	336	335	358	399	399	402	389	398	438	490	544	608	731
Dept. of Defense	13,981	16,509	20,623	22,993	25,373	29,792	32,938	35,232	35,415	37,577	37,268	32,135	35,996	39,611	37,554
Dept. of Education	139	105	128	112	116	125	121	133	141	159	170	171	161	171	176
Dept. of Energy	4,754	4,918	4,708	4,537	4,674	4,966	4,688	4,757	5,036	5,193	5,631	5,983	5,975	6,080	5,921
Dept. of Health & Human Services	3,780	3,927	3,941	4,353	4,831	5,451	5,658	6,609	7,158	7,903	8,406	9,756	10,812	10,402	10,722
National Institutes of Health	3,182	3,333	3,433	3,789	4,257	4,828	5,005	5,853	6,291	6,778	7,137	7,696	8,408	9,788	10,079
Dept. of Housing & Urban Development	56	48	29	32	18	19	15	16	18	18	19	28	25	26	35
Dept. of the Interior	411	427	381	383	411	392	385	404	417	469	509	593	610	604	599
Dept. of Labor	138	62	25	20	16	13	10	22	36	35	73	44	52	61	63
Dept. of Transportation	361	416	310	348	448	429	386	324	304	303	366	380	442	715	727
Dept. of Veterans Affairs	133	144	137	161	190	227	186	210	215	235	238	217	288	305	259
Agency for International Development	149	134	200	227	237	220	251	218	204	279	335	378	373	373	333
Environmental Protection Agency	345	326	335	241	261	320	317	348	347	380	420	433	487	503	540
National Aeronautics & Space Admin	3,234	3,593	3,078	2,662	2,822	3,327	3,420	3,787	4,330	5,393	6,533	7,280	7,658	8,190	8,637
National Science Foundation	882	962	975	1,062	1,203	1,346	1,353	1,471	1,533	1,670	1,690	1,785	1,846	2,069	2,221
Nuclear Regulatory Commission	183	220	220	207	191	150	124	123	109	115	218	109	119	120	122
All other agencies	253	211	208	193	210	242	232	254	266	241	248	278	406	364	337
	Basic research														
Total, all agencies	4,674	5,041	5,482	6,260	7,067	7,819	8,153	8,944	9,474	10,602	11,286	12,171	13,602	13,715	13,923
Dept. of Agriculture	276	314	331	362	393	445	433	445	481	485	519	558	595	597	631
Dept. of Commerce	16	16	17	19	21	23	27	26	31	29	31	34	35	37	40
Dept. of Defense	540	604	687	786	848	861	924	908	877	948	948	994	1,132	1,266	1,251
Dept. of Education	18	21	14	14	12	15	5	3	4	4	5	9	5	5	5
Dept. of Energy	523	586	642	768	830	943	960	1,068	1,185	1,411	1,505	1,686	1,721	1,764	1,752
Dept. of Health & Human Services	1,763	1,900	2,145	2,475	2,815	3,233	3,339	3,830	4,081	4,388	4,649	5,050	6,170	5,694	5,777
National Institutes of Health	1,642	1,767	2,021	2,313	2,625	3,018	3,119	3,577	3,795	4,053	4,262	4,590	5,057	5,688	5,774
Dept. of Housing & Urban Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of the Interior	72	81	77	103	126	138	133	135	126	189	205	229	230	227	213
Dept. of Labor	4	4	7	5	5	3	1	1	1	1	*	*	7	6	6
Dept. of Transportation	0	1	1	1	4	1	1	0	0	0	0	0	1	4	2
Dept. of Veterans Affairs	14	15	13	14	16	15	15	17	17	17	16	16	16	14	12
Agency for International Development	0	0	0	4	3	2	4	3	3	3	5	6	6	7	6
Environmental Protection Agency	14	11	33	22	30	39	39	31	27	51	73	91	111	110	78
National Aeronautics & Space Admin	559	531	536	617	755	751	917	1,014	1,113	1,417	1,637	1,706	1,738	1,952	1,991
National Science Foundation	815	897	916	999	1,132	1,262	1,275	1,371	1,433	1,563	1,586	1,676	1,721	1,918	2,051
Nuclear Regulatory Commission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All other agencies	61	61	65	70	80	88	83	93	95	96	106	115	114	114	108

(continued)

Appendix table 4–10.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1980–94

(page 2 of 6)

Agency	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
	Millions of current dollars														
Applied research															
Total, all agencies	6,923	7,172	7,541	7,993	7,911	8,315	8,349	8,999	9,176	10,163	10,453	11,798	12,527	14,094	13,696
Dept. of Agriculture	382	427	436	456	442	466	464	473	505	517	550	618	666	671	670
Dept. of Commerce	239	233	259	266	276	301	313	313	311	322	346	415	452	488	551
Dept. of Defense	1,721	1,997	2,266	2,437	2,201	2,307	2,303	2,440	2,362	2,708	2,582	2,724	2,860	3,865	3,007
Dept. of Education	70	33	56	62	69	77	91	104	107	118	125	123	116	121	128
Dept. of Energy	754	827	1,054	1,193	1,195	1,198	1,081	1,029	1,051	1,021	1,066	1,587	1,708	1,863	1,665
Dept. of Health & Human Services	1,570	1,592	1,461	1,545	1,652	1,796	1,851	2,195	2,416	2,700	2,818	3,112	3,560	3,582	3,689
National Institutes of Health	1,145	1,182	1,104	1,165	1,286	1,410	1,469	1,740	1,886	2,008	2,074	2,194	2,344	3,012	3,085
Dept. of Housing & Urban Development	20	17	10	11	6	7	5	6	6	6	7	9	9	10	14
Dept. of the Interior	283	289	275	255	254	231	235	247	266	253	270	324	340	342	350
Dept. of Labor	33	55	11	13	11	9	9	19	26	22	21	24	18	15	16
Dept. of Transportation	82	87	66	72	74	70	68	68	91	120	119	115	150	318	293
Dept. of Veterans Affairs	104	113	110	132	156	194	155	173	179	197	199	178	247	249	212
Agency for International Development	80	86	128	153	164	158	181	151	132	216	300	352	333	337	288
Environmental Protection Agency	232	208	211	152	142	176	179	246	241	223	242	262	296	316	383
National Aeronautics & Space Admin	1,051	876	871	928	955	1,033	1,152	1,256	1,219	1,461	1,424	1,666	1,491	1,606	2,105
National Science Foundation	58	59	57	63	71	84	78	99	100	108	103	109	125	151	170
Nuclear Regulatory Commission	183	220	220	207	191	150	124	123	109	115	218	109	119	120	122
All other agencies	63	53	49	49	53	59	61	57	56	56	64	71	37	40	33
Development															
Total, all agencies	18,233	20,891	23,410	24,458	27,246	32,226	34,910	37,313	38,285	40,640	41,928	37,327	40,992	43,738	42,745
Dept. of Agriculture	30	33	31	30	31	32	32	29	31	36	39	61	66	77	85
Dept. of Commerce	88	79	60	50	62	75	60	64	47	47	61	40	58	83	139
Dept. of Defense	11,719	13,908	17,670	19,770	22,324	26,623	29,711	31,884	32,176	33,921	33,739	28,417	32,003	34,479	33,297
Dept. of Education	52	51	58	36	35	33	26	26	30	37	40	39	39	45	42
Dept. of Energy	3,476	3,505	3,012	2,576	2,649	2,825	2,648	2,659	2,801	2,761	3,060	2,709	2,546	2,453	2,504
Dept. of Health & Human Services	447	435	335	332	365	423	468	584	661	814	939	1,594	1,082	1,126	1,256
National Institutes of Health	394	385	309	311	347	400	418	536	610	717	801	913	1,007	1,089	1,220
Dept. of Housing & Urban Development	36	31	19	21	12	12	10	11	12	12	13	18	16	16	21
Dept. of the Interior	57	57	30	25	31	22	17	22	24	27	33	40	39	35	35
Dept. of Labor	102	4	8	2	0	1	1	1	9	13	51	20	27	40	41
Dept. of Transportation	279	327	243	275	371	358	317	256	213	182	247	265	291	393	432
Dept. of Veterans Affairs	16	17	14	15	18	18	16	19	19	21	22	23	25	41	35
Agency for International Development	70	48	72	71	70	61	66	64	69	60	29	20	34	28	39
Environmental Protection Agency	100	107	92	66	89	106	100	71	80	107	104	79	80	78	79
National Aeronautics & Space Admin	1,624	2,186	1,671	1,117	1,113	1,544	1,351	1,518	1,999	2,515	3,473	3,909	4,428	4,632	4,541
National Science Foundation	8	6	2	0	0	0	0	0	0	0	0	0	0	0	0
Nuclear Regulatory Commission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All other agencies	129	97	94	73	77	95	88	106	114	87	78	92	258	212	199

(continued)

Appendix table 4–10.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1980–94

(page 3 of 6)

Agency	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
	Millions of current dollars														
R&D plant															
Total, all agencies	1,556	1,486	1,390	1,298	1,787	1,821	1,539	1,846	2,057	2,967	2,284	3,695	3,360	3,901	3,791
Dept. of Agriculture	57	21	21	34	39	41	79	112	135	124	102	145	165	196	93
Dept. of Commerce	5	1	1	1	9	4	9	5	11	16	15	16	27	158	148
Dept. of Defense	208	278	291	313	529	531	286	477	436	615	487	1,253	323	309	216
Dept. of Education	0	0	0	0	0	1	7	21	5	2	9	4	2	2	2
Dept. of Energy	1,024	978	914	758	852	868	742	772	915	1,043	916	1,220	1,790	1,912	2,089
Dept. of Health & Human Services	31	24	25	48	31	42	38	37	20	131	108	86	73	116	129
National Institutes of Health	29	22	19	18	28	29	29	35	19	130	85	68	68	116	129
Dept. of Housing & Urban Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of the Interior	8	3	1	2	5	4	4	12	9	12	14	22	18	7	12
Dept. of Labor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of Transportation	23	19	12	22	17	9	12	11	14	19	22	18	25	53	39
Dept. of Veterans Affairs	4	15	3	11	6	3	5	6	20	11	3	3	6	9	10
Agency for International Development	6	8	6	5	8	7	8	7	6	0	13	15	0	0	0
Environmental Protection Agency	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0
National Aeronautics & Space Admin	159	116	114	101	244	234	275	309	428	853	527	724	818	991	872
National Science Foundation	19	15	2	3	45	74	53	61	57	119	39	160	101	138	177
Nuclear Regulatory Commission	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0
All other agencies	4	1	1	1	1	2	20	15	1	22	27	29	8	8	4
R&D and R&D plant															
Total, all agencies	31,386	34,590	37,822	40,010	44,012	50,180	52,951	57,101	58,992	64,373	65,951	64,991	70,481	75,447	74,154
Dept. of Agriculture	745	795	819	881	905	984	1,008	1,060	1,152	1,162	1,211	1,381	1,492	1,540	1,479
Dept. of Commerce	347	329	337	336	368	403	409	407	400	414	454	505	571	766	879
Dept. of Defense	14,189	16,786	20,913	23,305	25,902	30,322	33,224	35,709	35,851	38,192	37,755	33,388	36,319	39,920	37,770
Dept. of Education	139	105	128	112	116	126	128	154	146	161	179	175	163	173	178
Dept. of Energy	5,778	5,896	5,622	5,294	5,526	5,834	5,431	5,529	5,951	6,236	6,547	7,203	7,765	7,992	8,010
Dept. of Health & Human Services	3,811	3,951	3,965	4,400	4,862	5,493	5,696	6,645	7,178	8,034	8,513	9,842	10,885	10,518	10,851
National Institutes of Health	3,211	3,356	3,453	3,807	4,285	4,857	5,035	5,889	6,310	6,908	7,221	7,763	8,476	9,904	10,208
Dept. of Housing & Urban Development	56	48	29	32	18	19	15	16	18	18	19	28	25	26	35
Dept. of the Interio	419	431	382	385	416	396	390	416	426	481	523	615	628	611	611
Dept. of Labor	138	62	25	20	16	13	10	22	36	35	73	44	52	61	63
Dept. of Transportation	385	434	322	370	465	438	398	336	318	322	387	398	467	768	766
Dept. of Veterans Affairs	138	159	140	172	196	230	191	215	235	246	241	220	294	314	269
Agency for International Development	156	142	206	232	245	227	259	224	211	279	348	393	373	373	333
Environmental Protection Agency	345	326	335	241	261	320	317	348	347	380	420	433	491	505	540
National Aeronautics & Space Admin	3,393	3,709	3,192	2,763	3,066	3,562	3,695	4,097	4,758	6,246	7,060	8,004	8,476	9,181	9,509
National Science Foundation	901	976	977	1,065	1,248	1,419	1,407	1,532	1,590	1,789	1,729	1,945	1,947	2,207	2,398
Nuclear Regulatory Commission	190	227	220	207	191	150	124	123	109	115	218	109	119	120	122
All other agencies	257	212	209	194	210	244	252	270	267	264	275	307	414	372	341

(continued)

Appendix table 4–10.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1980–94

(page 4 of 6)

Agency	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
	Millions of constant 1987 dollars														
	Total R&D														
Total, all agencies	42,253	42,550	43,580	44,496	46,452	51,283	52,948	55,255	54,957	56,752	56,493	52,479	55,888	58,167	55,844
Dept. of Agriculture	974	995	954	974	953	1,000	956	948	982	959	983	1,059	1,105	1,093	1,100
Dept. of Commerce	485	421	402	385	394	423	411	402	375	368	389	419	453	494	580
Dept. of Defense	19,803	21,219	24,668	26,429	27,913	31,592	33,922	35,232	34,184	34,729	33,068	27,513	29,972	32,204	29,805
Dept. of Education	197	135	153	128	127	132	125	133	136	147	151	146	134	139	140
Dept. of Energy	6,733	6,322	5,632	5,215	5,141	5,266	4,828	4,757	4,861	4,799	4,996	5,123	4,975	4,943	4,699
Dept. of Health & Human Services	5,354	5,048	4,714	5,003	5,314	5,780	5,827	6,609	6,909	7,304	7,458	8,353	9,002	8,457	8,510
National Institutes of Health	4,507	4,284	4,107	4,355	4,684	5,120	5,155	5,853	6,072	6,264	6,332	6,589	7,001	7,958	7,999
Dept. of Housing & Urban Development	79	62	35	37	20	20	16	16	17	17	17	24	21	21	28
Dept. of the Interior	583	549	456	440	452	415	397	404	403	433	451	508	508	491	475
Dept. of Labor	196	80	30	23	18	14	11	22	35	32	65	38	43	50	50
Dept. of Transportation	512	534	371	400	493	455	397	324	293	280	324	325	368	581	577
Dept. of Veterans Affairs	189	186	164	186	209	240	192	210	208	217	211	185	240	248	206
Agency for International Development	211	172	239	261	261	234	259	218	197	258	297	323	311	303	264
Environmental Protection Agency	489	419	401	277	287	340	327	348	335	351	372	370	405	409	429
National Aeronautics & Space Admin	4,581	4,619	3,682	3,059	3,104	3,528	3,522	3,787	4,180	4,984	5,797	6,233	6,376	6,659	6,855
National Science Foundation	1,249	1,236	1,167	1,221	1,323	1,427	1,394	1,471	1,480	1,543	1,499	1,528	1,537	1,682	1,763
Nuclear Regulatory Commission	259	282	264	238	210	159	127	123	105	106	193	93	99	98	97
All other agencies	358	272	249	221	231	256	239	254	257	223	220	238	338	296	267
	Basic research														
Total, all agencies	6,621	6,480	6,557	7,196	7,775	8,291	8,397	8,944	9,145	9,799	10,014	10,420	11,326	11,150	11,050
Dept. of Agriculture	391	404	396	416	432	472	446	445	464	448	461	477	495	485	501
Dept. of Commerce	23	21	20	22	23	25	27	26	30	27	28	29	29	30	32
Dept. of Defense	765	777	821	903	933	913	951	908	847	876	841	851	943	1,029	993
Dept. of Education	25	26	17	16	13	15	5	3	4	4	4	7	4	4	4
Dept. of Energy	741	754	768	882	914	1,000	988	1,068	1,144	1,304	1,335	1,444	1,433	1,434	1,390
Dept. of Health & Human Services	2,497	2,443	2,565	2,845	3,096	3,428	3,439	3,830	3,939	4,055	4,125	4,324	5,137	4,629	4,585
National Institutes of Health	2,326	2,271	2,417	2,659	2,888	3,200	3,212	3,577	3,663	3,746	3,781	3,929	4,211	4,624	4,583
Dept. of Housing & Urban Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of the Interior	101	104	92	118	139	147	137	135	122	175	182	196	192	185	169
Dept. of Labor	6	5	8	6	6	3	1	1	1	1	0	0	6	5	5
Dept. of Transportation	0	2	1	1	4	1	1	0	0	0	0	0	1	3	2
Dept. of Veterans Affairs	20	19	15	16	17	16	15	17	17	15	14	14	13	11	10
Agency for International Development	0	0	0	5	3	2	4	3	3	3	4	5	5	6	5
Environmental Protection Agency	19	13	39	26	33	41	40	31	26	47	65	78	92	89	62
National Aeronautics & Space Admin	792	683	641	709	830	796	944	1,014	1,074	1,310	1,452	1,460	1,447	1,587	1,580
National Science Foundation	1,155	1,152	1,096	1,148	1,246	1,338	1,313	1,371	1,383	1,445	1,408	1,435	1,433	1,559	1,628
Nuclear Regulatory Commission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All other agencies	87	78	77	81	88	93	85	93	91	89	94	99	95	93	86

(continued)

Appendix table 4–10.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1980–94

(page 5 of 6)

Agency	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
	Millions of constant 1987 dollars														
	Applied research														
Total, all agencies	9,806	9,218	9,020	9,188	8,703	8,817	8,598	8,999	8,857	9,393	9,275	10,101	10,430	11,459	10,870
Dept. of Agriculture	541	549	521	524	486	494	477	473	487	478	488	529	555	546	532
Dept. of Commerce	338	300	310	305	304	319	322	313	300	298	307	356	376	397	437
Dept. of Defense	2,438	2,566	2,711	2,801	2,421	2,446	2,372	2,440	2,280	2,503	2,291	2,332	2,381	3,142	2,387
Dept. of Education	99	43	67	71	76	82	94	104	103	109	111	105	97	98	102
Dept. of Energy	1,068	1,063	1,261	1,372	1,314	1,271	1,113	1,029	1,014	944	946	1,359	1,422	1,515	1,321
Dept. of Health & Human Services	2,224	2,046	1,747	1,776	1,817	1,904	1,906	2,195	2,332	2,495	2,501	2,665	2,964	2,912	2,928
National Institutes of Health	1,622	1,519	1,320	1,339	1,414	1,495	1,513	1,740	1,820	1,856	1,840	1,878	1,952	2,449	2,448
Dept. of Housing & Urban Development	28	21	12	13	7	7	5	6	6	6	6	8	7	8	11
Dept. of the Interior	401	372	329	293	280	245	242	247	257	234	239	277	283	278	278
Dept. of Labor	46	70	13	15	12	10	9	19	25	20	19	21	15	12	13
Dept. of Transportation	117	112	79	82	82	74	70	68	88	111	106	98	125	259	233
Dept. of Veterans Affairs	147	145	132	152	172	205	160	173	173	182	177	152	206	202	168
Agency for International Development	113	111	153	175	180	168	186	151	128	200	266	301	277	274	229
Environmental Protection Agency	328	267	252	175	157	187	185	246	233	206	214	224	246	257	304
National Aeronautics & Space Admin	1,488	1,126	1,042	1,066	1,050	1,095	1,187	1,256	1,177	1,350	1,263	1,426	1,241	1,306	1,671
National Science Foundation	83	76	68	72	78	89	80	99	97	100	92	93	104	123	135
Nuclear Regulatory Commission	259	282	264	238	210	159	127	123	105	106	193	93	99	98	97
All other agencies	90	68	59	57	59	62	63	57	54	52	57	61	31	33	26
	Development														
Total, all agencies	25,826	26,852	28,003	28,113	29,974	34,174	35,953	37,313	36,955	37,560	37,204	31,958	34,132	35,559	33,925
Dept. of Agriculture	43	42	37	34	34	34	33	29	30	33	35	52	55	63	67
Dept. of Commerce	125	101	72	58	68	79	61	64	45	43	54	34	48	67	110
Dept. of Defense	16,599	17,876	21,136	22,724	24,559	28,232	30,598	31,884	31,058	31,350	29,937	24,330	26,647	28,032	26,426
Dept. of Education	73	66	69	41	38	35	26	26	29	34	35	34	32	37	33
Dept. of Energy	4,924	4,505	3,603	2,960	2,914	2,996	2,727	2,659	2,704	2,552	2,715	2,320	2,120	1,994	1,987
Dept. of Health & Human Services	634	559	401	381	401	448	482	584	638	752	833	1,364	901	915	997
National Institutes of Health	559	495	369	357	382	424	430	536	589	663	710	781	838	885	968
Dept. of Housing & Urban Development	52	40	22	24	13	13	10	11	12	11	11	16	13	13	17
Dept. of the Interior	80	74	35	29	34	24	18	22	23	25	30	34	32	28	28
Dept. of Labor	144	5	10	2	0	1	1	1	9	12	46	17	22	33	33
Dept. of Transportation	395	420	291	316	408	379	327	256	206	168	219	227	242	320	343
Dept. of Veterans Affairs	22	21	17	18	20	19	17	19	19	19	20	20	21	33	28
Agency for International Development	99	61	86	81	77	64	68	64	67	55	26	17	28	23	31
Environmental Protection Agency	142	138	110	76	98	112	102	71	77	99	93	68	67	63	63
National Aeronautics & Space Admin	2,301	2,810	1,998	1,284	1,224	1,637	1,391	1,518	1,930	2,324	3,081	3,347	3,687	3,766	3,604
National Science Foundation	11	8	3	0	0	0	0	0	0	0	0	0	0	0	0
Nuclear Regulatory Commission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
All other agencies	182	125	113	84	85	101	90	106	110	80	70	79	215	172	158

(continued)

Appendix table 4–10.

Federal obligations for R&D and R&D plant, by agency and character of work: FYs 1980–94

(page 6 of 6)

Agency	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
	Millions of constant 1987 dollars														
R&D plant															
Total, all agencies	2,204	1,910	1,662	1,492	1,966	1,931	1,585	1,846	1,986	2,742	2,026	3,164	2,798	3,172	3,009
Dept. of Agriculture	81	27	26	39	43	43	82	112	130	115	91	124	137	159	74
Dept. of Commerce	7	2	1	1	10	4	10	5	11	15	14	14	22	128	117
Dept. of Defense	295	357	347	359	582	563	295	477	421	568	432	1,073	269	251	171
Dept. of Education	0	0	0	0	0	1	7	21	5	2	8	4	2	2	2
Dept. of Energy	1,450	1,257	1,093	871	938	921	764	772	883	964	813	1,045	1,490	1,554	1,658
Dept. of Health & Human Services	3	30	30	55	34	45	39	37	19	121	96	74	61	94	102
Dept. of Housing & Urban Development	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of the Interior	11	4	2	3	6	4	4	12	9	11	12	19	15	6	10
Dept. of Labor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dept. of Transportation	33	24	14	25	19	10	12	11	13	18	19	16	21	43	31
Dept. of Veterans Affairs	6	19	3	12	7	3	5	6	19	10	3	3	5	7	8
Agency for International Development	9	10	7	6	9	7	8	7	6	0	12	13	0	0	0
Environmental Protection Agency	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0
National Aeronautics & Space Admin	225	149	136	116	269	248	283	309	413	788	468	620	681	806	692
National Science Foundation	26	19	2	4	50	78	55	61	55	110	35	137	84	112	140
Nuclear Regulatory Commission	11	10	0	0	0	0	0	0	0	0	0	0	0	0	0
R&D and R&D plant															
Total, all agencies	44,456	44,460	45,242	45,988	48,418	53,214	54,533	57,101	56,942	59,494	58,519	55,643	58,685	61,339	58,852
Dept. of Agriculture	1,055	1,022	979	1,013	996	1,043	1,038	1,060	1,112	1,074	1,074	1,183	1,242	1,252	1,174
Dept. of Commerce	492	423	403	386	404	427	421	407	386	383	402	433	475	623	698
Dept. of Defense	20,098	21,576	25,016	26,788	28,495	32,155	34,216	35,709	34,605	35,298	33,501	28,586	30,241	32,455	29,976
Dept. of Education	197	135	153	128	127	134	132	154	141	149	159	150	136	141	141
Dept. of Energy	8,184	7,579	6,725	6,086	6,079	6,187	5,593	5,529	5,744	5,763	5,809	6,167	6,465	6,498	6,357
Dept. of Health & Human Services	5,398	5,078	4,743	5,058	5,349	5,825	5,866	6,645	6,928	7,425	7,554	8,427	9,063	8,551	8,612
Dept. of Housing & Urban Development	79	62	35	37	20	20	16	16	17	17	17	24	21	21	28
Dept. of the Interior	593	553	457	442	458	420	401	416	412	445	464	527	523	497	485
Dept. of Labor	196	80	30	23	18	14	11	22	35	32	65	38	43	50	50
Dept. of Transportation	545	558	385	425	512	464	409	336	307	298	344	341	389	624	608
Dept. of Veterans Affairs	195	205	168	198	216	244	197	215	227	227	214	188	245	255	213
Agency for International Development	220	183	246	267	270	241	266	224	203	258	309	336	311	303	264
Environmental Protection Agency	489	419	401	277	287	340	327	348	335	351	372	370	409	411	429
National Aeronautics & Space Admin	4,806	4,767	3,818	3,176	3,373	3,777	3,805	4,097	4,593	5,773	6,265	6,853	7,057	7,464	7,547
National Science Foundation	1,275	1,255	1,168	1,224	1,373	1,505	1,449	1,532	1,535	1,653	1,534	1,665	1,621	1,794	1,903
Nuclear Regulatory Commission	270	292	264	238	210	159	127	123	105	106	193	93	99	98	97

* = less than $500,000

NOTES: Data for 1993–94 are estimates. Data for 1992–94 are from the Clinton administration's 1994 budget proposal: They differ from the figures in appendix tables 4–11 through 4–16, which are derived from National Science Foundation surveys of federal agencies. See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993.* (Washington DC: NSF, 1993); and Office of Management and Budget, unpublished tabulations.

See figure 4–13 and 4–14.

Appendix table 4–11.

Estimated federal obligations for R&D, by selected agency, performer, and character of work: FY 1993

Agency	Total	Federal intramural	Industrial firms	FFRDCs admin. by industry	Univers. and colleges	FFRDCs admin. by U&C	Other non-profits	FFRDCs admin. by nonprofits	State & local govt.	Foreign
	Millions of dollars									
Total R&D										
Total, all agencies	69,754	16,643	31,203	2,142	11,764	3,703	2,957	721	286	336
Dept. of Agriculture	1,337	899	9	*	416	0	7	0	3	4
Dept. of Commerce	623	477	88	0	50	*	3	*	5	*
Dept. of Defense	36,155	8,277	24,543	315	1,558	558	272	447	1	185
Dept. of Energy	6,731	567	1,242	1,759	576	2,203	164	216	4	2
Dept. of Health & Human Services	11,143	2,361	452	21	6,284	35	1,719	26	187	59
Dept. of the Interior	541	482	13	*	40	0	1	0	3	2
Dept. of Transportation	493	262	158	1	32	0	9	15	15	1
Environmental Protection Agency	520	116	214	0	123	*	38	0	28	0
National Aeronautics & Space Admin	8,629	2,646	4,288	0	675	750	252	2	5	12
National Science Foundation	2,247	16	102	1	1,838	135	143	*	4	8
All other agencies	1,336	541	94	45	171	23	349	16	34	63
Basic research										
Total, all agencies	14,184	2,893	1,104	227	7,070	1,468	1,228	79	59	55
Dept. of Agriculture	642	416	3	0	215	0	4	0	1	2
Dept. of Commerce	40	36	*	0	3	*	*	0	0	*
Dept. of Defense	1,162	333	94	1	682	11	31	0	*	11
Dept. of Energy	1,873	57	36	215	405	971	120	68	*	1
Dept. of Health & Human Services	5,849	1,113	212	11	3,530	21	870	9	50	31
Dept. of the Interior	195	179	1	0	12	0	1	0	3	0
Dept. of Transportation	0	0	0	0	0	0	0	0	0	0
Environmental Protection Agency	116	12	51	0	52	*	0	0	0	0
National Aeronautics & Space Admin	2,060	597	613	0	453	331	60	1	1	4
National Science Foundation	2,094	15	91	1	1,710	135	132	*	4	7
All other agencies	154	135	2	0	7	*	11	0	1	0
Applied research										
Total, all agencies	13,715	4,948	2,955	451	3,183	916	976	101	94	92
Dept. of Agriculture	630	420	6	*	198	0	2	0	2	1
Dept. of Commerce	494	406	40	0	43	*	1	*	5	*
Dept. of Defense	3,365	1,401	1,392	21	449	55	30	10	0	6
Dept. of Energy	1,748	262	195	376	137	684	29	61	2	*
Dept. of Health & Human Services	3,460	803	181	7	1,840	10	529	14	58	20
Dept. of the Interior	311	280	4	*	25	0	1	0	1	2
Dept. of Transportation	210	85	91	1	19	0	8	1	4	1
Environmental Protection Agency	319	93	122	0	59	0	27	0	19	0
National Aeronautics & Space Admin	2,103	888	857	0	147	145	61	*	1	4
National Science Foundation	153	1	11	0	127	*	11	*	1	1
All other agencies	921	309	57	45	138	23	276	15	3	56
Development										
Total, all agencies	41,855	8,802	27,144	1,464	1,511	1,318	753	541	133	189
Dept. of Agriculture	65	63	0	0	2	0	*	0	*	*
Dept. of Commerce	89	36	47	0	5	*	1	*	0	0
Dept. of Defense	31,628	6,542	23,056	293	427	492	211	438	1	169
Dept. of Energy	3,111	248	1,011	1,168	34	548	14	86	1	*
Dept. of Health & Human Services	1,834	445	59	3	914	4	320	2	78	8
Dept. of the Interior	35	23	9	0	3	0	0	0	0	0
Dept. of Transportation	283	176	68	*	13	0	1	14	11	0
Environmental Protection Agency	84	11	41	0	12	0	11	0	9	0
National Aeronautics & Space Admin	4,465	1,161	2,817	0	75	274	131	1	2	4
National Science Foundation	0	0	0	0	0	0	0	0	0	0
All other agencies	260	97	36	*	26	*	63	0	31	8

* = less than $500,000; FFRDC = federally funded research and development center; U&C = universities and colleges

NOTE: These figures reflect funding levels as reported by federal agencies in March through October 1992. They differ from the figures in appendix table 4–10, which reflect subsequent congressional appropriation actions through March 1993.

SOURCE: Science Resources Studies Division, National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993* (Washington, DC: NSF, 1993).

See text table 4–3.

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Appendix table 4–12.

Federal obligations for R&D, by character of work and performer: FYs 1983–93

(page 1 of 2)

Character of work and performer	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992 (est.)	1993 (est.)
	Millions of current dollars										
Total research and development	38,712	42,225	48,360	51,412	55,253	56,769	61,406	63,667	61,295	70,368	69,754
Federal intramural[1]	10,582	11,572	12,945	13,535	13,413	14,115	15,121	16,002	15,238	16,635	16,643
Industrial firms excluding FFRDCs	17,020	18,610	21,705	24,201	26,768	26,719	28,548	29,378	26,421	32,156	31,203
FFRDCs administered by industry	1,501	1,608	1,791	1,697	1,860	1,911	1,960	2,237	2,068	2,178	2,142
Universities and colleges excluding FFRDCs	4,966	5,547	6,340	6,559	7,337	7,828	8,672	9,142	10,169	11,298	11,764
FFRDCs administered by universities	2,394	2,486	2,816	2,768	3,210	3,474	3,497	3,466	3,604	3,831	3,703
Nonprofit institutions excluding FFRDCs	1,242	1,497	1,699	1,677	1,711	1,683	1,999	2,249	2,637	2,944	2,957
FFRDCs administered by nonprofit institutions	581	597	689	551	511	506	522	632	679	713	721
State and local government	186	131	129	128	148	142	167	214	215	275	286
Foreign	240	176	245	296	296	392	919	345	264	339	336
Basic research	6,260	7,067	7,819	8,153	8,942	9,474	10,602	11,286	12,171	13,254	14,184
Federal intramural[1]	1,690	1,861	1,923	2,019	2,046	2,050	2,371	2,366	2,447	2,705	2,893
Industrial firms excluding FFRDCs	293	378	380	512	467	597	773	888	950	1,041	1,104
FFRDCs administered by industry	83	91	123	118	120	133	167	175	209	221	228
Universities and colleges excluding FFRDCs	3,112	3,531	4,039	4,132	4,666	4,868	5,221	5,548	6,065	6,603	7,070
FFRDCs administered by universities	604	669	724	724	907	990	1,098	1,228	1,306	1,387	1,469
Nonprofit institutions excluding FFRDCs	410	474	556	572	658	729	839	924	1,016	1,120	1,228
FFRDCs administered by nonprofit institutions	8	8	12	13	13	18	42	59	81	70	79
State and local government	32	28	31	31	38	43	44	50	49	56	59
Foreign	29	28	31	33	29	46	47	48	49	52	56
Applied research	7,993	7,911	8,315	8,349	8,998	9,176	10,163	10,453	11,798	12,941	13,715
Federal intramural[1]	3,020	2,904	3,133	3,142	3,392	3,288	3,611	3,587	4,093	4,451	4,948
Industrial firms excluding FFRDCs	1,821	1,760	1,694	1,769	1,982	2,046	2,102	2,312	2,457	2,762	2,955
FFRDCs administered by industry	440	405	363	365	314	322	353	367	416	468	451
Universities and colleges excluding FFRDCs	1,356	1,499	1,688	1,751	1,975	2,155	2,572	2,593	2,803	3,022	3,183
FFRDCs administered by universities	646	667	697	568	564	575	605	581	855	931	916
Nonprofit institutions excluding FFRDCs	427	449	489	491	550	571	681	738	910	1,005	976
FFRDCs administered by nonprofit institutions	77	79	85	75	77	65	67	89	90	104	101
State and local government	105	60	59	60	53	60	78	76	80	107	94
Foreign	101	89	107	130	93	94	95	109	94	91	92
Development	24,458	27,246	32,226	34,910	37,313	38,119	40,640	41,929	37,327	44,172	41,855
Federal intramural[1]	5,872	6,808	7,889	8,375	7,975	8,776	9,139	10,049	8,699	9,478	8,802
Industrial firms excluding FFRDCs	14,906	16,473	19,631	21,921	24,320	24,077	25,673	26,178	23,014	28,353	27,144
FFRDCs administered by industry	979	1,112	1,305	1,215	1,426	1,456	1,440	1,695	1,444	1,488	1,464
Universities and colleges excluding FFRDCs	499	517	614	675	697	805	879	1,001	1,301	1,673	1,511
FFRDCs administered by universities	1,143	1,150	1,395	1,476	1,739	1,909	1,794	1,658	1,443	1,513	1,318
Nonprofit institutions excluding FFRDCs	405	575	654	614	503	383	480	587	712	820	753
FFRDCs administered by nonprofit institutions	496	510	592	463	421	423	412	484	509	539	541
State and local government	49	43	40	37	58	39	46	88	86	112	133
Foreign	110	59	107	134	173	251	777	188	121	196	189

(continued)

Appendix table 4–12.

Federal obligations for R&D, by character of work and performer: FYs 1983–93

(page 2 of 2)

Character of work and performer	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992 (est.)	1993 (est.)
	Millions of constant 1987 dollars[2]										
Total research and development	44,496	46,452	51,283	52,948	55,253	54,796	56,752	56,492	52,479	58,591	56,711
Federal intramural[1]	12,163	12,731	13,728	13,939	13,413	13,625	13,975	14,199	13,046	13,851	13,531
Industrial firms excluding FFRDCs	19,563	20,473	23,017	24,924	26,768	25,791	26,384	26,067	22,621	26,774	25,368
FFRDCs administered by industry	1,726	1,769	1,899	1,748	1,860	1,845	1,811	1,985	1,771	1,813	1,741
Universities and colleges excluding FFRDCs	5,709	6,102	6,723	6,755	7,337	7,556	8,015	8,112	8,706	9,407	9,564
FFRDCs administered by universities	2,752	2,735	2,986	2,851	3,210	3,353	3,232	3,075	3,086	3,190	3,011
Nonprofit institutions excluding FFRDCs	1,427	1,647	1,802	1,727	1,711	1,625	1,848	1,996	2,258	2,451	2,404
FFRDCs administered by nonprofit institutions	668	657	731	567	511	488	482	561	581	594	586
State and local government	214	144	137	132	148	137	154	190	184	229	233
Foreign	193	259	305	296	378	849	306	226	282	273	
Basic research	7,196	7,775	8,291	8,397	8,942	9,145	9,799	10,014	10,420	11,036	11,532
Federal intramural[1]	1,942	2,047	2,040	2,079	2,046	1,979	2,191	2,099	2,095	2,252	2,352
Industrial firms excluding FFRDCs	337	416	403	527	467	576	714	788	813	867	898
FFRDCs administered by industry	95	100	130	121	120	128	154	155	179	184	185
Universities and colleges excluding FFRDCs	3,577	3,884	4,283	4,256	4,666	4,699	4,825	4,923	5,193	5,498	5,748
FFRDCs administered by universities	694	736	768	746	907	956	1,015	1,090	1,118	1,155	1,194
Nonprofit institutions excluding FFRDCs	471	521	589	589	658	704	775	820	870	933	998
FFRDCs administered by nonprofit institutions	9	9	13	13	13	17	39	52	69	58	64
State and local government	37	31	32	32	38	42	41	44	42	47	48
Foreign	33	30	33	34	29	44	43	43	42	43	46
Applied research	9,188	8,703	8,817	8,598	8,998	8,857	9,393	9,275	10,101	10,775	11,150
Federal intramural[1]	3,472	3,194	3,322	3,235	3,392	3,174	3,337	3,183	3,504	3,706	4,023
Industrial firms excluding FFRDCs	2,093	1,936	1,796	1,822	1,982	1,975	1,943	2,051	2,104	2,300	2,402
FFRDCs administered by industry	505	446	385	375	314	311	326	326	356	390	367
Universities and colleges excluding FFRDCs	1,558	1,649	1,790	1,804	1,975	2,080	2,377	2,301	2,400	2,516	2,588
FFRDCs administered by universities	743	734	739	585	564	555	559	516	732	775	745
Nonprofit institutions excluding FFRDCs	491	494	519	506	550	551	629	655	779	837	793
FFRDCs administered by nonprofit institutions	89	87	90	77	77	63	62	79	77	87	82
State and local government	120	66	62	62	53	58	72	67	68	89	76
Foreign	116	98	113	134	93	91	88	97	80	76	75
Development	28,113	29,974	34,174	35,953	37,313	36,794	37,560	37,204	31,958	36,779	34,028
Federal intramural[1]	6,749	7,489	8,366	8,625	7,975	8,471	8,446	8,917	7,448	7,892	7,156
Industrial firms excluding FFRDCs	17,133	18,122	20,818	22,576	24,320	23,240	23,727	23,228	19,704	23,608	22,068
FFRDCs administered by industry	1,125	1,223	1,384	1,251	1,426	1,405	1,331	1,504	1,236	1,239	1,190
Universities and colleges excluding FFRDCs	573	569	651	695	697	777	812	888	1,114	1,393	1,228
FFRDCs administered by universities	1,314	1,265	1,479	1,520	1,739	1,843	1,658	1,471	1,235	1,260	1,072
Nonprofit institutions excluding FFRDCs	465	632	694	632	503	370	444	521	610	683	612
FFRDCs administered by nonprofit institutions	570	561	628	477	421	408	381	429	436	449	440
State and local government	57	47	42	39	58	38	43	78	74	93	108
Foreign	126	65	113	138	173	242	718	167	104	163	154

FFRDC = federally funded research and development center

[1] Federal intramural activities cover costs associated with the planning and administration of intramural and extramural programs by federal personnel and actual intramural performance.

[2] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCE: Science Resources Studies Division, National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993* (Washington, DC: NSF, 1993).

Appendix table 4–13.

Federal R&D obligations for federal intramural performance, by selected agency: FYs 1980–93

	All agencies	Defense	Energy	NASA	HHS	USDA	Commerce	Interior	All other agencies
	Millions of dollars								
1980	7,632	3,796	474	965	820	457	226	242	653
1981	8,426	4,281	451	1,044	872	511	237	274	756
1982	9,141	5,139	176	1,166	946	531	242	261	680
1983	10,582	6,401	258	1,134	1,034	559	252	274	670
1984	11,572	7,257	216	1,043	1,066	589	256	334	811
1985	12,945	8,324	224	1,171	1,147	628	280	342	830
1986	13,535	8,881	206	1,217	1,236	630	285	332	749
1987	13,413	8,336	248	1,414	1,293	649	320	355	799
1988	14,115	8,880	245	1,335	1,408	694	316	353	883
1989	15,121	9,295	248	1,733	1,529	689	325	394	907
1990	16,003	9,639	307	1,968	1,662	737	336	424	929
1991	15,238	8,157	381	2,112	1,975	824	400	490	900
1992 (est.)	16,635	8,791	498	2,362	2,245	885	426	526	902
1993 (est.)	16,643	8,277	567	2,646	2,361	899	477	482	935

HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; USDA = Department of Agriculture

NOTES: Intramural activities cover costs associated with the planning and administration of intramural and extramural R&D programs by federal personnel and actual intramural R&D performance. Data includes expenditures for activities performed by the reporting agency itself, and funds that the agency transfers to another federal agency for performance of work as long as the ultimate performer is that agency or any federal agency.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955–1990* (Washington, DC: NSF, 1990); and SRS, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993* (Washington, DC: NSF, 1993).

Science & Engineering Indicators – 1993

Appendix table 4–14.

Federal R&D obligations to federally funded research and development centers, by administering sector and selected agency: FYs 1980–93

	All agencies	Defense	Energy	NASA	All other agencies
	Millions of dollars				
FFRDCs administered by universities and colleges					
1980	1,533	149	1,185	97	102
1981	1,791	186	1,400	79	126
1982	1,977	226	1,439	183	129
1983	2,394	388	1,564	305	136
1984	2,486	262	1,714	350	160
1985	2,816	306	1,848	512	150
1986	2,768	285	1,797	542	143
1987	3,210	737	1,839	475	158
1988	3,474	829	1,945	560	141
1989	3,497	686	2,033	630	148
1990	3,466	658	2,020	619	168
1991	3,604	637	2,072	736	159
1992 (est.)	3,831	645	2,233	773	181
1993 (est.)	3,703	558	2,203	750	193
FFRDCs administered by industry					
1980	1,408	92	1,166	0	150
1981	1,414	105	1,155	0	154
1982	1,506	148	1,194	0	164
1983	1,501	129	1,218	0	154
1984	1,608	110	1,365	0	134
1985	1,791	125	1,549	0	117
1986	1,697	146	1,455	0	96
1987	1,860	325	1,475	0	61
1988	1,911	316	1,536	0	60
1989	1,960	309	1,588	0	63
1990	2,238	419	1,718	0	100
1991	2,068	316	1,690	0	62
1992 (est.)	2,178	313	1,788	0	77
1993 (est.)	2,142	305	1,759	0	78
FFRDCs administered by nonprofit institutions					
1980	442	255	172	1	15
1981	525	319	184	1	22
1982	521	385	114	0	21
1983	581	466	92	0	22
1984	597	473	104	0	19
1985	689	551	118	1	19
1986	551	436	102	1	13
1987	511	400	96	1	14
1988	506	397	91	1	16
1989	522	391	107	3	20
1990	632	416	157	2	57
1991	679	442	186	2	49
1992 (est.)	713	449	208	2	55
1993 (est.)	721	447	216	2	56

FFRDC = federally funded research and development center; NASA = National Aeronautics and Space Administration

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955–1990* (Washington, DC: NSF, 1990); and SRS, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993* (Washington, DC: NSF, 1993).

Science & Engineering Indicators – 1993

Appendix table 4-15.

Federal obligations for basic research, by science and engineering field: FYs 1980-93

(page 1 of 2)

Field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992 (est.)	1993 (est.)
	Millions of current dollars													
Total, all fields	4,674	5,041	5,482	6,260	7,067	7,819	8,153	8,944	9,474	10,602	11,286	12,171	13,254	14,184
Life sciences	2,054	2,224	2,526	2,891	3,288	3,787	3,859	4,364	4,502	4,916	5,178	5,434	6,145	6,622
Biological & agricultural, total	1,340	1,462	1,675	1,929	2,175	2,516	2,543	2,870	2,856	3,102	3,219	3,375	3,773	4,071
Biological (excl. environmental)	1,100	1,202	1,401	1,622	1,836	2,106	2,152	2,462	2,415	2,647	2,742	2,868	3,214	3,476
Environmental biology	86	83	83	93	121	126	126	141	147	157	168	187	206	222
Agricultural	154	177	190	214	218	284	266	268	294	298	309	319	353	373
Medical sciences, total	657	706	793	879	1,015	1,145	1,197	1,343	1,573	1,708	1,850	1,858	2,145	2,299
Other life sciences	58	55	58	84	98	126	119	151	73	104	109	201	227	252
Psychology	84	91	90	93	108	133	133	147	188	187	215	226	249	265
Physical sciences	1,221	1,325	1,394	1,587	1,728	1,815	1,914	2,096	2,200	2,506	2,662	2,881	3,063	3,249
Astronomy	279	274	271	355	380	401	453	505	459	525	580	612	698	782
Chemistry	257	298	312	362	403	425	433	445	471	505	502	539	581	629
Physics	668	735	791	855	921	960	1,003	1,072	1,206	1,395	1,474	1,645	1,663	1,709
Other physical sciences	16	17	20	15	24	30	25	74	65	82	105	85	121	128
Environmental sciences	522	533	520	580	657	700	749	781	873	1,017	1,275	1,264	1,387	1,510
Atmospheric science	179	174	163	173	192	209	240	244	281	316	444	449	514	578
Geological	198	194	178	178	198	250	266	266	267	335	440	499	535	556
Oceanography	131	143	155	196	220	219	224	250	269	294	300	198	211	237
Other environmental sciences	14	22	25	34	46	21	19	21	55	72	92	118	126	140
Mathematics & computer sciences	116	140	165	208	241	260	293	306	313	346	407	426	513	563
Mathematics	67	79	91	101	114	130	142	158	165	168	176	164	203	215
Computer sciences	46	52	67	90	105	116	131	129	125	160	225	224	275	313
Other math & computer sciences	3	9	7	17	22	14	20	20	22	18	5	38	36	35
Social sciences	147	137	120	138	133	141	114	130	147	155	146	161	161	172
Anthropology	14	13	13	11	17	16	11	12	12	12	13	13	13	15
Economics	40	34	39	41	30	34	26	29	35	38	37	37	40	40
Political science	7	6	4	5	4	6	4	6	5	5	6	7	7	8
Sociology	25	23	19	33	34	32	30	34	37	38	24	28	29	31
Other social sciences	60	61	45	48	48	52	42	48	58	61	66	76	72	80
Other sciences	64	65	56	73	69	100	122	131	255	292	302	546	339	373
Engineering	465	526	611	690	845	884	969	990	1,006	1,184	1,102	1,234	1,397	1,431
Aeronautical	104	113	127	141	226	192	226	237	231	328	270	256	284	315
Astronautical	27	33	45	50	52	42	53	49	48	59	62	70	75	83
Chemical	26	31	35	50	56	74	73	78	89	50	76	102	112	105
Civil	22	23	32	32	42	44	45	46	46	52	47	59	61	63
Electrical	71	79	94	96	130	145	156	175	154	174	147	142	169	180
Mechanical	42	47	53	61	64	88	84	87	84	101	91	116	134	149
Metallurgy & materials	121	139	156	183	187	212	229	210	230	255	260	295	304	330
Other engineering	52	61	69	76	88	88	103	108	124	166	148	194	257	206

(continued)

Appendix table 4-15.

Federal obligations for basic research, by science and engineering field: FYs 1980-93

(page 2 of 2)

Field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992 (est.)	1993 (est.)
	Millions of constant 1987 dollars[1]													
Total, all fields	6,621	6,480	6,557	7,196	7,775	8,291	8,397	8,944	9,145	9,799	10,014	10,420	11,036	11,532
Life sciences	2,910	2,858	3,022	3,323	3,617	4,015	3,974	4,364	4,346	4,543	4,594	4,652	5,117	5,383
Biological & agricultural, total	1,897	1,880	2,003	2,217	2,392	2,668	2,619	2,870	2,757	2,867	2,856	2,889	3,142	3,310
Biological (excl. environmental)	1,558	1,545	1,676	1,864	2,020	2,234	2,216	2,462	2,331	2,446	2,433	2,456	2,676	2,826
Environmental biology	122	107	100	107	133	133	129	141	142	145	149	160	172	181
Agricultural	217	228	228	246	240	301	274	268	284	275	274	273	294	303
Medical sciences, total	931	908	949	1,010	1,117	1,215	1,232	1,343	1,518	1,579	1,642	1,591	1,786	1,869
Other life sciences	82	71	69	96	107	133	123	151	70	96	97	172	189	205
Psychology	119	117	108	107	119	141	137	147	181	173	191	193	207	215
Physical sciences	1,729	1,703	1,667	1,824	1,901	1,925	1,972	2,096	2,124	2,316	2,362	2,467	2,550	2,641
Astronomy	396	352	324	407	418	425	467	505	443	485	515	524	582	636
Chemistry	364	383	373	416	444	451	446	445	455	467	445	461	484	512
Physics	946	945	946	983	1,014	1,018	1,033	1,072	1,164	1,289	1,308	1,408	1,384	1,389
Other physical sciences	23	22	24	18	26	31	25	74	63	76	93	73	101	104
Environmental sciences	740	685	622	667	722	742	771	781	843	940	1,131	1,082	1,155	1,228
Atmospheric science	254	223	195	198	211	222	248	244	271	292	394	384	428	470
Geological	281	250	212	205	218	265	273	266	258	310	390	427	446	452
Oceanography	185	184	185	225	242	233	231	250	260	272	266	169	176	192
Other environmental sciences	20	28	30	39	51	22	19	21	53	67	82	101	105	114
Mathematics & computer sciences	165	180	197	239	265	276	302	306	302	320	361	365	427	458
Mathematics	95	102	109	116	125	138	147	158	159	155	156	141	169	175
Computer sciences	65	67	81	104	115	123	135	129	121	148	200	191	229	254
Other math & computer sciences	5	12	8	19	24	14	20	20	21	17	4	33	30	29
Social sciences	208	176	144	158	146	149	117	130	142	143	130	138	134	140
Anthropology	20	17	16	13	18	17	12	12	12	11	12	11	11	12
Economics	57	44	47	47	33	36	27	29	34	35	33	32	33	32
Political science	10	8	5	5	5	6	4	6	5	5	5	6	6	6
Sociology	36	29	22	38	37	34	31	34	36	35	21	24	24	25
Other social sciences	85	78	54	55	53	56	43	48	56	56	59	65	60	65
Other sciences	91	84	67	84	76	106	126	131	246	270	268	467	282	303
Engineering	659	676	730	793	930	938	997	990	971	1,094	978	1,056	1,163	1,163
Aeronautical	148	146	151	162	248	203	233	237	223	303	240	219	236	256
Astronautical	39	43	54	58	58	44	54	49	46	55	55	60	63	67
Chemical	37	40	42	58	61	79	75	78	86	46	67	87	93	85
Civil	31	30	38	37	46	46	47	46	44	48	42	51	51	51
Electrical	100	101	112	110	143	154	161	175	149	161	130	122	141	146
Mechanical	60	61	64	70	71	94	86	87	81	93	81	99	112	121
Metallurgy & materials	172	178	186	210	206	225	235	210	222	236	231	252	254	269
Other engineering	73	78	83	88	97	94	106	108	120	153	131	166	214	168

[1] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955–1990* (Washington, DC: NSF, 1990); and SRS, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993* (Washington, DC: NSF, 1993).

See figure 4–15.

Appendix table 4-16.
Federal obligations for applied research, by science and engineering field: FYs 1980–93
(page 1 of 2)

Field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992 (est.)	1993 (est.)
	Millions of current dollars													
Total, all fields	6,923	7,172	7,541	7,993	7,911	8,315	8,349	8,999	9,176	10,163	10,453	11,798	12,941	13,715
Life sciences	2,138	2,212	2,220	2,287	2,348	2,576	2,606	2,980	3,223	3,579	3,660	4,188	4,443	4,717
Biological & agricultural, total	1,168	1,249	1,137	1,136	1,150	1,240	1,318	1,488	1,718	1,917	1,967	2,223	2,310	2,344
Biological (excl. environmental)	731	795	678	684	727	779	842	1,041	1,267	1,336	1,403	1,543	1,602	1,649
Environmental biology	144	137	100	101	129	135	138	149	154	210	174	273	291	287
Agricultural	294	317	359	351	294	326	338	299	297	371	391	407	418	408
Medical sciences, total	880	904	980	1,049	1,098	1,223	1,164	1,324	1,368	1,514	1,533	1,603	1,739	1,782
Other life sciences	90	59	103	102	100	113	123	168	137	148	160	363	395	591
Psychology	115	118	129	148	159	194	201	222	212	235	234	257	272	306
Physical sciences	780	896	1,107	1,304	1,241	1,231	1,155	1,157	1,118	1,199	1,147	1,354	1,471	1,541
Astronomy	6	7	5	3	3	14	15	18	12	17	17	19	9	10
Chemistry	198	189	169	158	203	225	229	235	232	278	260	290	329	321
Physics	514	610	820	1,000	915	856	803	781	770	795	781	816	921	977
Other physical sciences	62	90	113	144	120	135	108	122	103	108	90	229	213	233
Environmental sciences	739	588	628	671	619	704	733	731	734	756	899	886	973	993
Atmospheric science	231	200	263	288	242	277	281	309	307	272	330	354	363	387
Geological	203	202	180	155	161	179	178	176	174	208	221	230	253	239
Oceanography	131	118	107	148	143	179	205	178	191	198	220	201	218	239
Other environmental sciences	173	68	79	80	73	69	68	68	62	78	128	102	140	128
Mathematics & computer sciences	125	139	185	211	200	315	322	334	330	390	434	478	641	649
Mathematics	24	39	37	33	37	53	42	46	52	68	65	63	67	79
Computer sciences	82	69	104	124	110	164	171	169	167	205	337	361	504	499
Other math & computer sciences	18	31	44	55	53	97	109	119	110	116	32	53	70	72
Social sciences	377	361	266	298	304	319	302	351	339	396	484	566	629	546
Anthropology	3	2	2	2	2	2	2	3	2	2	2	3	4	4
Economics	153	173	118	125	118	125	105	120	125	129	160	150	157	149
Political science	5	5	3	7	7	9	8	6	7	8	7	10	12	10
Sociology	46	42	33	35	36	34	37	40	45	56	92	156	163	138
Other social sciences	170	140	110	130	141	149	150	183	160	202	223	247	294	245
Other sciences	286	314	231	247	262	242	261	307	271	350	362	358	421	459
Engineering	2,365	2,545	2,776	2,828	2,779	2,733	2,770	2,917	2,950	3,258	3,234	3,711	4,091	4,504
Aeronautical	604	596	615	680	635	547	549	573	571	659	658	760	883	1,053
Astronautical	275	271	246	271	344	383	474	576	527	619	519	583	584	689
Chemical	70	116	60	95	89	180	173	138	169	92	166	203	238	204
Civil	137	136	170	156	161	173	158	159	169	178	270	246	291	325
Electrical	447	478	519	519	500	482	518	611	577	669	493	587	590	658
Mechanical	166	157	148	206	126	179	153	146	157	157	177	220	208	246
Metallurgy & materials	115	118	153	150	154	227	217	152	227	266	294	415	448	363
Other engineering	552	673	866	751	770	563	529	562	553	619	657	696	847	968

(continued)

Appendix table 4-16.

Federal obligations for applied research, by science and engineering field: FYs 1980–93

(page 2 of 2)

Field	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992 (est.)	1993 (est.)
	Millions of constant 1987 dollars[1]													
Total, all fields	9,806	9,218	9,020	9,188	8,703	8,817	8,598	8,999	8,857	9,393	9,275	10,101	10,776	11,150
Life sciences	3,028	2,843	2,655	2,628	2,583	2,732	2,683	2,980	3,111	3,308	3,248	3,586	3,700	3,835
Biological & agricultural, total	1,655	1,606	1,360	1,305	1,265	1,315	1,358	1,488	1,658	1,772	1,745	1,903	1,923	1,905
Biological (excl. environmental)	1,035	1,022	811	786	800	826	867	1,041	1,223	1,235	1,245	1,321	1,333	1,341
Environmental biology	203	176	120	116	142	143	142	149	149	194	154	234	242	233
Agricultural	416	408	429	403	323	345	348	299	287	343	347	348	348	332
Medical sciences, total	1,246	1,162	1,172	1,205	1,207	1,297	1,199	1,324	1,320	1,399	1,360	1,372	1,448	1,449
Other life sciences	127	75	123	118	110	120	127	168	132	137	142	311	329	481
Psychology	163	152	154	170	175	206	207	222	205	217	208	220	227	249
Physical sciences	1,105	1,151	1,324	1,499	1,365	1,305	1,189	1,157	1,079	1,108	1,018	1,159	1,225	1,253
Astronomy	9	9	6	3	3	15	16	18	12	16	15	17	7	8
Chemistry	280	243	202	182	223	239	236	235	224	257	231	248	274	261
Physics	729	784	981	1,149	1,007	908	827	781	743	735	693	699	767	794
Other physical sciences	88	116	135	165	132	143	111	122	99	100	80	196	177	190
Environmental sciences	1,046	756	752	771	681	747	754	731	708	699	798	759	810	807
Atmospheric science	326	257	314	331	266	294	289	309	296	251	293	303	302	315
Geological	288	260	215	178	177	190	184	176	168	192	196	197	210	194
Oceanography	186	152	128	170	158	190	212	178	184	183	195	172	181	195
Other environmental sciences	245	88	94	92	80	73	70	68	60	72	114	87	116	104
Mathematics & computer sciences	177	178	221	243	219	334	332	334	319	360	385	409	533	528
Mathematics	34	50	45	37	41	57	43	46	50	63	58	54	56	64
Computer sciences	117	89	124	143	121	174	176	169	161	189	299	309	419	406
Other math & computer sciences	26	39	53	63	58	103	112	119	106	107	28	45	58	58
Social sciences	533	463	318	342	334	339	311	351	327	366	429	485	524	444
Anthropology	4	2	2	2	2	2	2	3	2	2	2	3	3	3
Economics	216	222	141	143	129	133	108	120	121	119	142	129	131	121
Political science	7	6	4	8	7	9	8	6	7	7	6	9	10	8
Sociology	65	54	40	40	40	36	38	40	43	52	82	133	136	112
Other social sciences	241	179	131	149	156	158	155	183	154	187	198	211	244	199
Other sciences	405	403	276	284	288	257	269	307	262	323	321	306	351	373
Engineering	3,350	3,272	3,321	3,250	3,057	2,899	2,853	2,917	2,847	3,011	2,870	3,177	3,406	3,662
Aeronautical	856	766	735	781	698	580	566	573	551	609	584	651	735	856
Astronautical	390	348	294	312	379	406	489	576	509	572	461	500	486	560
Chemical	99	149	72	109	98	191	178	138	163	85	147	173	198	166
Civil	194	175	203	179	177	183	163	159	163	165	240	210	242	264
Electrical	633	615	620	597	550	511	534	611	557	618	437	503	492	535
Mechanical	235	202	177	236	139	190	158	146	152	145	157	188	173	200
Metallurgy & materials	163	151	183	172	169	241	223	152	219	246	261	356	373	295
Other engineering	781	866	1,036	864	847	597	544	562	534	572	583	596	705	787

[1] See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Develoment, Detailed Historical Tables: Fiscal Years 1955–1990* (Washington, DC: NSF, 1990); and SRS, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993* (Washington, DC: NSF, 1993).

See figure 4-15.

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Appendix table 4–17.

Federal obligations for basic and applied research, by agency and field of science and engineering: FY 1991

Agency	Total	Life sciences	Psychology	Physical sciences	Environmental sciences	Math & computer sciences	Social sciences	Other sciences	Engineering
	Thousands of dollars								
Total, all agencies	23,968,377	9,621,981	482,400	4,235,336	2,149,783	903,705	903,411	727,290	4,944,471
Dept. of Agriculture	1,175,465	914,171	323	80,439	15,680	13,358	0	107,967	43,527
Dept. of Commerce	449,706	68,242	838	69,000	184,865	28,344	20,805	12,050	65,562
Dept. of Defense	3,717,908	304,812	97,328	574,706	262,666	380,536	157,243	2,598	1,938,019
Dept. of Education	131,666	16,883	4,961	0	0	1,804	0	102,606	5,412
Dept. of Energy	3,273,630	285,359	0	1,837,775	238,469	142,703	45,721	0	723,603
Dept. of Health & Human Services	8,162,487	6,805,987	344,105	142,276	0	18,225	456,683	318,881	76,330
Dept. of Housing & Urban Development	9,391	0	0	0	187	199	2,292	6,578	135
Dept. of the Interior	553,396	100,879	0	35,677	300,081	15,031	55	4,211	97,462
Dept. of Justice	21,075	442	863	0	0	1,050	2,891	14,529	1,300
Dept. of Labor	24,327	0	0	0	0	0	0	24,327	0
Dept. of State	5,854	0	0	0	0	0	0	5,854	0
Dept. of Transportation	114,624	4,160	2,658	2,788	2,421	16,327	719	6,619	78,932
Dept. of the Treasury	24,136	140	266	3,219	0	11,178	0	9,333	0
Dept. of Veterans Affairs	193,800	177,092	16,544	0	0	0	0	0	164
Advisory Com. on Intergov. Relations	1,663	0	0	0	0	0	0	1,663	0
Agency for International Development	357,371	304,539	0	0	0	4,112	23,472	24,342	906
Appalachian Regional Commission	742	0	0	0	0	0	0	742	0
Consumer Product Safety Commission	883	0	0	178	0	0	0	0	705
Environmental Protection Agency	353,139	156,122	1,235	52,119	76,420	4,480	1,841	0	60,922
Federal Communications Commission	1,442	0	0	0	0	75	0	439	928
Federal Trade Commission	957	0	0	0	0	0	0	957	0
International Trade Commission	9,885	0	0	0	0	0	0	9,885	0
Library of Congress	1,704	0	0	0	0	0	1,704	0	0
National Aeronautics & Space Admin.	3,371,162	174,544	11,366	939,726	667,739	79,932	19,779	126	1,477,950
National Archives & Records Admin.	611	0	0	541	0	70	0	0	0
National Science Foundation	1,785,223	269,308	1,913	467,150	393,317	186,281	164,219	40,366	262,669
Nuclear Regulatory Commission	108,800	0	0	0	0	0	0	0	108,800
Smithsonian Institution	97,999	35,484	0	22,786	7,188	0	0	32,541	0
Tennessee Valley Authority	18,841	3,817	0	6,956	750	0	5,987	481	850
U.S. Arms Control & Disarmament Agency	390	0	0	0	0	0	0	195	195
United States Information Agency	100	0	0	0	0	0	0	0	100

SOURCE: Science Resources Studies Division, National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993* (Washington, DC: NSF, 1993).

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Appendix table 4–18.
Department of Defense military outlays, by subfunction: 1970–94

	DOD outlays[1]	Personnel	O&M	Procurement	RDT&E	Construction	Housing
		Distribution by subfunction					
		Percent					
1970	81,173	35.8	26.6	26.6	8.8	1.4	0.8
1971	77,874	37.3	26.9	24.2	9.4	1.4	0.8
1972	78,054	37.9	27.8	21.9	10.1	1.4	0.9
1973	76,501	38.9	27.5	20.5	10.7	1.5	1.0
1974	79,001	38.5	28.5	19.3	10.9	1.8	1.1
1975	85,953	37.4	30.6	18.7	10.3	1.7	1.3
1976	88,481	36.8	31.5	18.0	10.1	2.3	1.3
1977	95,504	35.3	32.0	19.0	10.3	2.0	1.4
1978	102,954	34.5	32.6	19.4	10.2	1.9	1.4
1979	113,893	32.8	32.0	22.3	9.8	1.8	1.3
1980	131,963	31.0	33.9	22.0	9.9	1.9	1.3
1981	154,474	31.0	33.6	22.8	9.9	1.6	1.1
1982	180,780	30.5	33.0	23.9	9.8	1.6	1.1
1983	205,646	29.6	31.6	26.1	10.0	1.7	1.0
1984	222,661	28.8	30.3	27.8	10.4	1.7	1.1
1985	244,599	27.7	29.6	28.8	11.1	1.7	1.1
1986	263,485	27.1	28.6	29.0	12.3	1.9	1.1
1987	271,326	26.5	28.1	29.8	12.4	2.2	1.1
1988	281,726	27.1	30.0	27.4	12.3	2.1	1.1
1989	294,831	27.4	29.5	27.7	12.6	1.8	1.1
1990	290,973	26.0	30.4	27.8	12.9	1.7	1.2
1991	308,618	27.0	33.0	26.6	11.2	1.1	1.1
1992	290,259	28.0	31.7	25.8	11.9	1.5	1.1
1993	281,692	27.0	32.3	24.3	13.3	1.9	1.2
1994	268,624	26.1	33.2	23.1	14.2	2.0	1.4

DOD = Department of Defense; O&M = operations and maintenance; RDT&E = research, development, test, and evaluation

NOTES: Outlays exclude expenditures by the Army Corps of Engineers. Total DOD outlays and subfunction shares include only the categories listed here; they exclude adjustments reported in an undefined "other" category.

[1] DOD outlays are in millions of current dollars.

SOURCE: Office of Management and Budget, *Budget of the United States Government* (Washington, DC: Government Printing Office, annual series).

See figure 4–18.

Appendix table 4–19.
Department of Defense funds for research, development, test, and evaluation, by mission category: FYs 1972–94

	DOD RDT&E total	Technology base	Advanced technology development	Strategic programs	Tactical programs	Intelligence & communications	Defensewide mission support
	Millions of dollars						
1972	7,945	1,462	238	1,581	3,019	493	1,152
1973	8,001	1,376	160	1,896	2,936	528	1,104
1974	8,009	1,353	200	1,882	2,811	665	1,097
1975	8,572	1,371	300	2,143	2,923	643	1,192
1976	9,212	1,487	557	2,222	2,895	887	1,164
1977	10,522	1,682	537	2,333	3,848	830	1,293
1978	11,117	1,799	502	2,329	4,644	559	1,284
1979	12,210	2,010	525	2,139	5,088	759	1,689
1980	13,345	2,265	604	2,165	5,233	1,152	1,926
1981	16,472	2,600	593	3,440	6,130	1,632	2,077
1982	19,897	2,933	751	4,636	6,890	2,160	2,527
1983	22,647	3,238	823	5,825	7,255	2,709	2,797
1984	26,601	3,055	1,352	7,878	7,929	3,406	2,981
1985	30,870	3,121	2,751	8,169	9,062	3,953	3,814
1986	33,676	3,232	4,067	7,509	10,266	4,525	4,077
1987	35,942	3,237	5,032	7,703	11,032	4,702	4,236
1988	37,027	3,310	5,356	7,227	11,998	4,885	4,251
1989	37,506	3,506	5,837	6,428	12,989	4,512	4,234
1990	36,632	3,345	5,833	5,192	13,237	4,791	4,234
1991	34,871	3,886	5,298	4,375	12,611	4,471	4,230
1992	38,118	4,105	6,314	4,240	14,313	4,921	4,225
1993	38,176	4,920	4,053	6,345	14,131	4,702	4,025
1994	38,620	4,376	3,607	4,776	15,904	5,113	4,844
	Percentage of total						
1972	100.0	18.4	3.0	19.9	38.0	6.2	14.5
1973	100.0	17.2	2.0	23.7	36.7	6.6	13.8
1974	100.0	16.9	2.5	23.5	35.1	8.3	13.7
1975	100.0	16.0	3.5	25.0	34.1	7.5	13.9
1976	100.0	16.1	6.0	24.1	31.4	9.6	12.6
1977	100.0	16.0	5.1	22.2	36.6	7.9	12.3
1978	100.0	16.2	4.5	20.9	41.8	5.0	11.5
1979	100.0	16.5	4.3	17.5	41.7	6.2	13.8
1980	100.0	17.0	4.5	16.2	39.2	8.6	14.4
1981	100.0	15.8	3.6	20.9	37.2	9.9	12.6
1982	100.0	14.7	3.8	23.3	34.6	10.9	12.7
1983	100.0	14.3	3.6	25.7	32.0	12.0	12.4
1984	100.0	11.5	5.1	29.6	29.8	12.8	11.2
1985	100.0	10.1	8.9	26.5	29.4	12.8	12.4
1986	100.0	9.6	12.1	22.3	30.5	13.4	12.1
1987	100.0	9.0	14.0	21.4	30.7	13.1	11.8
1988	100.0	8.9	14.5	19.5	32.4	13.2	11.5
1989	100.0	9.3	15.6	17.1	34.6	12.0	11.3
1990	100.0	9.1	15.9	14.2	36.1	13.1	11.6
1991	100.0	11.1	15.2	12.5	36.2	12.8	12.1
1992	100.0	10.8	16.6	11.1	37.5	12.9	11.1
1993	100.0	12.9	10.6	16.6	37.0	12.3	10.5
1994	100.0	11.3	9.3	12.4	41.2	13.2	12.5

DOD = Department of Defense; RDT&E = research, development, test, and evaluation

NOTE: Data are DOD's total obligational authority.

SOURCES: Science Resources Studies Division, National Science Foundation, *Federal R&D Funding by Budget Function* (Washington, DC: NSF, annual series); and DOD, *RDT&E Programs (R-1)* (Washington, DC: DOD, annual series).

See figure 4–18.

Appendix table 4–20.

Federal funding of academic research, by mode of support and selected civilian agency: FYs 1980, 1983, 1986, and 1989

Agency	1980	1983	1986	1989
	Millions of dollars			
Six civilian agencies	3,579	4,156	5,503	7,261
Individual investigators	2,003	2,384	3,030	3,677
Research teams	968	1,018	1,465	2,218
Research centers	482	575	705	920
Major facilities	126	179	291	438
Other support	0	0	12	9
National Institutes of Health	2,061	2,437	3,327	4,445
Individual investigators	1,100	1,395	1,774	2,171
Research teams	681	738	1,154	1,752
Research centers	273	299	386	484
Major facilities	7	5	13	38
National Science Foundation	719	880	1,163	1,438
Individual investigators	512	610	768	885
Research teams	68	84	123	164
Research centers	21	25	51	112
Major facilities	119	162	221	277
Department of Energy	337	321	422	560
Individual investigators	137	131	192	230
Research teams	160	125	109	168
Research centers	41	65	78	91
Major facilities	0	0	43	72
National Aeronautics & Space Admin.[1]	173	189	244	404
Individual investigators	115	118	143	216
Research teams	57	69	77	133
Research centers	0	0	7	27
Major facilities	1	2	5	19
Other support	0	0	12	9
Department of Agriculture	225	282	281	356
Individual investigators	75	90	91	129
Research teams	3	3	2	2
Research centers	147	180	179	193
Major facilities	0	10	9	32
Environmental Protection Agency	64	45	65	59
Individual investigators	64	40	62	47
Research teams	0	0	0	0
Research centers	0	5	4	12
Major facilities	0	0	0	0

[1] Totals for 1980 are 1981 data.

SOURCE: Office of Science and Technology Policy, *Trends in the Structure of Federal Science Support* report of the Federal Coordinating Council for Science, Engineering, and Technology (Washington, DC: Government Printing Office, 1992).

See figures 4–16 and 5–5.

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Appendix table 4–21.
Federal budget authority proposed for FCCSET research initiatives, by agency and research theme: FY 1994

Agency	Advanced manufacturing technology	High-performance computing & communications	U.S. global change	Advanced materials & processing	Biotechnology	Science, math, engineering, & tech. ed.
			Millions of dollars			
Total, all agencies	1,385	1,000	1,476	2,061	4,298	2,334
Dept. of Agriculture	50	0	48	46	191	24
Dept. of Commerce	141	14	70	57	14	6
Dept. of Defense	596	385	7	422	94	539
Dept. of Education	0	2	0	0	0	356
Dept. of Energy	367	124	98	946	245	128
Dept. of Health & Human Services	0	47	2	93	3,369	464
Dept. of the Interior	64	0	34	22	6	90
Dept. of Transportation	0	0	0	13	0	0
Dept. of Veterans Affairs	0	0	0	0	72	0
Agency for International Development [1]	0	0	0	0	31	0
Environmental Protection Agency	1	12	27	4	20	10
National Aeronautics & Space Admin	36	111	1,013	131	40	84
National Science Foundation	130	305	170	328	216	622
Smithsonian Institution[1]	0	0	7	0	0	10

FCCSET = Federal Coordinating Council for Science, Engineering, and Technology

[1] The Agency for International Development and the Smithsonian Institution are not members of the full FCCSET.

NOTE: Funding estimates are proposals included in the President's FY 1994 budget. Precise comparisons between FCCSET initiatives and the federal R&D support totals are difficult because the definitions for the two sets of data are not necessarily identical and there may be some double counting for closely related activities that are included in more than one initiative.

SOURCE: Office of Management and Budget, *FCCSET Initiatives in the FY 1994 Budget* (Washington, DC: April 8, 1993).

See figure 4–17.

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Appendix table 4–22.

Annual aggregate data on independent research and development: FYs 1976–92

	Independent research and development							DOD and NASA R&D obligations		IR&D as a percentage of	
		Accepted by Government IR&D program									
	Incurred by industry	Total accepted	DOD share	NASA share	Not reimbursed	Not accepted under IR&D program	DOD and NASA IR&D reimbursement	Total	Total to industry[1]	DOD and NASA R&D total[2] (a)	DOD and NASA R&D performed by industry[2] (b)
	Millions of current dollars									Percent	
1976	1,388	1,061	544	41	476	327	585	13,102	8,143	4.5	7.2
1977	1,560	1,199	598	46	555	361	644	14,134	9,109	4.6	7.1
1978	1,788	1,365	643	49	673	423	692	14,887	9,458	4.6	7.3
1979	2,104	1,517	708	54	755	587	762	16,084	10,079	4.7	7.6
1980	2,373	1,728	812	57	859	645	869	17,215	11,038	5.0	7.9
1981	2,796	2,039	1,056	66	917	757	1,122	20,102	13,028	5.6	8.6
1982	3,654	2,821	1,338	67	1,416	833	1,405	23,701	15,375	5.9	9.1
1983	4,017	2,961	1,601	78	1,282	1,056	1,679	25,654	15,700	6.5	10.7
1984	5,173	3,897	1,884	86	1,927	1,276	1,970	28,195	17,340	7.0	11.4
1985	5,036	3,500	2,099	88	1,313	1,536	2,187	33,119	20,645	6.6	10.6
1986	5,042	3,537	2,198	77	1,262	1,505	2,275	36,358	23,232	6.3	9.8
1987	4,885	3,544	2,186	67	1,291	1,341	2,253	39,019	25,721	5.8	8.8
1988	4,825	3,694	2,181	89	1,424	1,131	2,270	39,746	25,572	5.7	8.9
1989	4,866	3,798	2,233	110	1,455	1,068	2,331	42,970	27,469	5.4	8.5
1990	4,910	3,766	2,158	131	1,477	1,144	2,331	43,801	28,147	5.3	8.3
1991	5,099	4,327	2,203	133	1,991	772	2,331	39,415	24,701	5.9	9.4
1992	4,798	4,173	2,133	147	1,893	625	2,331	46,170	30,133	5.0	7.7
	Millions of constant 1987 dollars[3]										
1976	2,711	2,072	1,063	80	930	639	1,143	25,589	15,904		
1977	2,816	2,164	1,079	83	1,002	652	1,162	25,513	16,442		
1978	3,000	2,290	1,079	82	1,129	710	1,161	24,978	15,870		
1979	3,252	2,345	1,094	83	1,167	907	1,178	24,860	15,579		
1980	3,361	2,448	1,150	81	1,217	914	1,231	24,384	15,634		
1981	3,594	2,621	1,357	85	1,179	973	1,442	25,838	16,745		
1982	4,371	3,374	1,600	80	1,694	996	1,681	28,350	18,392		
1983	4,617	3,403	1,840	90	1,474	1,214	1,930	29,488	18,046		
1984	5,691	4,287	2,073	95	2,120	1,404	2,167	31,017	19,076		
1985	5,340	3,712	2,226	93	1,392	1,629	2,319	35,121	21,893		
1986	5,193	3,643	2,264	79	1,300	1,550	2,343	37,444	23,926		
1987	4,885	3,544	2,186	67	1,291	1,341	2,253	39,019	25,721		
1988	4,657	3,566	2,105	86	1,375	1,092	2,191	38,364	24,684		
1989	4,497	3,510	2,064	102	1,345	987	2,154	39,714	25,387		
1990	4,357	3,342	1,915	116	1,311	1,015	2,068	38,865	24,975		
1991	4,366	3,705	1,886	114	1,705	661	1,996	33,746	21,148		
1992	3,995	3,475	1,776	123	1,577	520	1,941	38,443	25,090		

DOD = Department of Defense; IR&D = independent research and development; NASA = National Aeronautics and Space Administration

[1] Includes R&D performed by federally funded research and development centers administered by industry.

[2] Percentages were calculated as follows: numerator in (a) is total DOD and NASA IR&D reimbursements, and denominator is total DOD and NASA R&D, excluding IR&D; numerator in (b) is total DOD and NASA IR&D reimbursements, and denominator is DOD and NASA R&D performed by industry, excluding IR&D.

[3] See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Defense Contract Audit Agency, *Summary of Independent Research and Development and Bid and Proposal Cost* (Washington, DC: DCAA, ongoing series); NASA, unpublished tabulations; Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Development, Detailed Historical Tables: Fiscal Years 1955-1990* (Washington, DC: NSF, 1990); and SRS, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993* (Washington, DC: NSF, 1993).

Appendix table 4–23.
Small Business Innovation Research awards, by award type and agency: FYs 1983–91

Award type and agency	1983	1984	1985	1986	1987	1988	1989	1990	1991	Cumulative 1983–91
					Millions of current dollars					
Total[1]	45	108	199	298	351	389	432	461	483	2,765
By type										
Phase I awards	45	48	69	99	110	102	108	118	128	825
Phase II awards	0	60	130	199	241	285	322	342	336	1,915
By agency										
Dept. of Defense	20	45	78	151	194	208	233	241	241	1,410
Dept. of Health & Human Services	7	23	45	57	67	73	79	84	93	528
National Aeronautics & Space Admin	5	13	29	36	32	47	52	62	69	346
Dept. of Energy	5	16	26	29	28	30	33	39	39	246
National Science Foundation	5	7	10	15	17	17	19	20	22	131
Dept. of Agriculture	1	2	3	4	4	4	4	4	5	29
Dept. of Transportation	*	2	3	4	3	3	4	4	6	29
Environmental Protection Agency	*	1	2	3	3	3	3	3	4	22
Dept. of Education	*	1	1	2	2	2	2	2	3	15
Nuclear Regulatory Commission	*	1	1	1	1	1	1	1	*	8
Dept. of Commerce	0	0	0	1	2	1	1	1	1	7
Dept. of the Interior	*	1	*	0	0	0	0	0	0	1
					Millions of constant 1987 dollars[2]					
Total[1]	51	119	211	307	351	376	399	409	414	2,637
By type										
Phase I awards	51	53	73	101	110	98	100	105	110	801
Phase II awards	0	66	138	205	241	275	297	303	288	1,813
By agency										
Dept. of Defense	23	49	83	155	194	201	216	213	206	1,340
Dept. of Health & Human Services	8	26	48	58	67	70	73	75	80	505
National Aeronautics & Space Admin	6	15	31	37	32	46	48	55	59	329
Dept. of Energy	6	18	27	30	28	29	31	35	33	237
National Science Foundation	6	8	10	15	17	17	17	17	19	126
Dept. of Agriculture	1	2	3	4	4	4	4	4	4	30
Dept. of Transportation	*	2	3	4	3	3	3	4	5	27
Environmental Protection Agency	*	1	2	3	3	3	3	3	3	21
Dept. of Education	*	1	1	2	2	2	2	2	2	14
Nuclear Regulatory Commission	*	1	1	1	1	0	1	1	*	6
Dept. of Commerce	0	0	0	1	2	1	1	1	1	7
Dept. of the Interior	*	1	*	0	0	0	0	0	0	1

* = less than $500,000

[1] Totals are Small Business Innovation Research award obligations that include award modifications. The details by award type and agency do not necessarily contain subsequent year revisions and may not add to totals.

[2] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCE: Small Business Administration, *Small Business Innovation Development Act* (Washington, DC: SBA, annual series).

Appendix table 4–24.

Small Business Innovation Research awards, by technology area and selected agency: FYs 1983–91 (cumulative)

Technology area[1]	Total	DOD	HHS	NASA	DOE	NSF	Other[2]
				Percent			
Total (1983–91)	100	100	100	100	100	100	100
Computer, information processing, analysis	21	26	15	25	9	18	19
Electronics	21	29	8	20	18	17	11
Materials	16	18	6	16	24	26	14
Mechanical performance of vehicles, weapons, facilities	6	8	1	12	3	4	4
Energy conservation and use	12	10	3	15	30	10	6
Environment & natural resources	7	5	4	7	11	12	20
Life sciences	16	4	65	4	4	13	26
				Millions of dollars			
Award value (1983-91)							
Assigned to (multiple) technology areas	4,244	1,990	758	610	482	206	198
Actual phase I and II award value	2,765	1,410	528	346	246	131	111

DOD = Department of Defense; DOE = Department of Energy; HHS = Department of Health and Human Services; NASA = National Aeronautics and Space Administration; NSF = National Science Foundation

[1] Distributions are based on the cumulative 1983-91 value of awards, not on the number of awards granted. Within each of the broad technology areas listed, Small Business Innovation Research awards are assigned to more specific technology areas, including multiple technology areas. Therefore, the percentage distributions include overcounting of awards assigned to multiple technology areas.

[2] Includes the Departments of Agriculture, Commerce, Education, and Transportation; the Environmental Protection Agency; and the Nuclear Regulatory Commission.

SOURCE: Small Business Administration, *Small Business Innovation Development Act* (Washington, DC: SBA, 1992).

See figure 4–22.

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Appendix table 4–25.

Budgetary impact of the federal research and experimentation tax credit: FYs 1981–94

	Cost of R&E credit[1]		Total federal R&D outlays	Ratio of credit outlays to R&D	Cost of R&E credit		Total federal R&D outlays
	Outlay equivalent (a)	Revenue loss (b)	(c)	(a)/(c)	Outlay equivalent	Revenue loss	
	Millions of current dollars			Percent	Millions of constant 1987 dollars[2]		
1981	205	15	32,459	0.63	263	19	41,721
1982	640	415	34,391	1.86	766	496	41,138
1983	1,010	615	36,659	2.76	1,161	707	42,137
1984	3,360	1,380	39,691	8.47	3,696	1,518	43,664
1985	2,430	1,665	44,171	5.50	2,577	1,766	46,841
1986	2,295	680	50,609	4.53	2,364	700	52,120
1987	2,715	1,865	51,612	5.26	2,715	1,865	51,612
1988	1,240	900	54,739	2.27	1,197	869	52,837
1989	1,590	1,145	59,450	2.67	1,470	1,058	54,945
1990	1,625	1,115	62,247	2.61	1,442	989	55,232
1991	1,070	725	61,130	1.75	916	621	52,337
1992	1,850	1,215	64,642	2.86	1,540	1,012	53,823
1993	775	520	68,576	1.13	630	423	55,753
1994	325	215	70,335	0.46	258	171	55,821

R&E = research and experimentation

NOTES: Tax expenditure estimates are prepared by the Treasury Department based on income tax law enacted as of December 31st of the year for which the expenditures are reported. Expenditures for the years 1992-94 are estimated based on income tax law enacted as of December 31, 1992. Legislation authorizing the R&E credit expired on June 30, 1992.

[1] "Outlay equivalent" estimates are comparable to taxable outlay figures reported in the budget. This allows a comparison of the resource cost of the tax credit with the cost of direct federal R&D expenditure support. The "revenue loss" estimates are net of taxes.

[2] See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCE: Office of Management and Budget, *Budget of the United States Government* (Washington, DC: Government Printing Office, annual series).

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Appendix table 4–26.

Federal R&D funding, by budget function: FYs 1980–94

Function	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993 (est.)	1994 (est.)
	Millions of current dollars														
Total	29,739	33,735	36,115	38,768	44,214	49,887	53,249	57,069	59,106	62,115	63,781	65,898	68,398	70,175	71,648
National defense	14,946	18,413	22,070	24,936	29,287	33,698	36,926	39,152	40,099	40,665	39,925	39,328	40,083	41,539	41,978
Health	3,694	3,871	3,869	4,298	4,779	5,418	5,565	6,556	7,076	7,773	8,308	9,226	10,055	10,279	10,636
Space research and technology	2,738	3,111	2,584	2,134	2,300	2,725	2,894	3,398	3,683	4,555	5,765	6,511	6,744	6,880	6,724
General science	1,233	1,340	1,359	1,502	1,676	1,862	1,873	2,042	2,160	2,373	2,410	2,635	2,659	2,715	2,990
Energy	3,603	3,501	3,012	2,578	2,581	2,389	2,286	2,053	2,126	2,419	2,715	2,943	3,099	2,648	2,855
Natural resources and environment	999	1,061	965	952	963	1,059	1,062	1,133	1,160	1,255	1,386	1,582	1,688	1,708	1,790
Transportation	887	869	791	876	1,040	1,030	917	908	896	1,064	1,045	1,231	1,523	1,784	1,970
Agriculture	585	659	693	745	762	836	815	822	882	907	950	1,052	1,155	1,153	1,170
Education, training, employment, & soc. svcs.	468	298	228	189	200	220	248	267	285	347	374	433	365	375	382
International affairs	125	160	165	177	192	210	211	223	224	279	375	378	371	382	333
Veterans benefits and services	126	143	139	157	218	193	183	215	195	212	216	219	245	251	224
Commerce and housing credit	101	106	104	107	110	114	111	110	122	128	140	178	192	222	386
Community and regional development	119	104	63	44	46	50	88	99	108	74	78	98	127	133	117
Administration of justice	45	34	31	37	24	47	41	49	51	45	44	51	51	51	49
Income security	47	43	32	32	26	21	14	25	23	27	33	30	37	52	39
General government	22	22	10	6	8	17	14	17	17	15	17	4	4	4	4
	Millions of constant 1987 dollars[1]														
Total	42,123	43,361	43,200	44,561	48,640	52,902	54,839	57,069	57,052	57,408	56,594	56,420	56,951	57,053	56,863
National defense	21,170	23,667	26,400	28,662	32,219	35,735	38,029	39,152	38,706	37,583	35,426	33,671	33,375	33,772	33,316
Health	5,232	4,976	4,628	4,940	5,257	5,745	5,731	6,556	6,830	7,184	7,372	7,899	8,372	8,357	8,441
Space research and technology	3,878	3,999	3,091	2,453	2,530	2,890	2,980	3,398	3,555	4,210	5,115	5,574	5,615	5,593	5,337
General science	1,746	1,722	1,626	1,726	1,844	1,975	1,929	2,042	2,085	2,193	2,138	2,256	2,214	2,207	2,373
Energy	5,103	4,500	3,603	2,963	2,839	2,533	2,354	2,053	2,052	2,236	2,409	2,520	2,580	2,153	2,266
Natural resources and environment	1,415	1,364	1,154	1,094	1,059	1,123	1,094	1,133	1,120	1,160	1,230	1,354	1,405	1,389	1,421
Transportation	1,256	1,117	946	1,007	1,144	1,092	944	908	865	983	927	1,054	1,268	1,450	1,563
Agriculture	829	847	829	856	838	887	839	822	851	838	843	901	962	937	929
Education, training, employment, & soc. svcs.	663	383	273	217	220	233	255	267	275	321	332	371	304	305	303
International affairs	177	206	197	203	211	223	217	223	216	258	333	324	309	311	264
Veterans benefits and services	178	184	166	180	240	205	188	215	188	196	192	188	204	204	178
Commerce and housing credit	143	136	124	123	121	121	114	110	118	118	124	153	160	180	306
Community and regional development	169	134	75	51	51	53	91	99	104	68	69	84	106	108	93
Administration of justice	64	44	37	43	26	50	42	49	49	42	39	44	42	41	39
Income security	67	55	38	37	29	22	14	25	22	25	29	26	31	42	31
General government	31	28	12	7	9	18	14	17	16	14	15	3	3	3	3

NOTE: Data for 1980–92 are actual budget authority. Data for 1993 and 1994 are estimates based on the FY 1994 budget.

[1] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division, National Science Foundation, *Selected Data on Federal R&D Funding by Budget Function: Fiscal Years 1992–94*, NSF 93-311 (Washington, DC: NSF, 1993).

See figure 4–9 and 4–10.

Appendix table 4–27.

Federal basic research funding, by budget function: FYs 1980–94

Function	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993 (est.)	1994 (est.)
	Millions of current dollars														
Total	4,716	5,107	5,305	6,247	7,072	7,810	8,193	9,021	9,553	10,648	11,288	12,405	12,973	13,497	13,760
Health	1,761	1,951	1,953	2,475	2,813	3,243	3,324	3,851	4,087	4,413	4,661	5,021	5,506	5,688	5,777
General science	1,152	1,256	1,296	1,439	1,606	1,779	1,795	1,942	2,061	2,265	2,306	2,526	2,532	2,577	2,820
Space research and technology	482	445	434	501	646	498	737	843	944	1,099	1,389	1,479	1,499	1,589	1,532
National defense	552	610	696	788	845	856	960	900	905	965	964	1,188	1,147	1,328	1,255
Energy	200	220	260	320	365	428	456	511	571	703	761	878	921	924	985
Agriculture	246	281	295	326	353	406	390	397	428	433	456	486	528	526	549
Natural resources and environment	136	131	139	156	192	206	204	206	210	331	336	389	383	374	374
Transportation	79	89	102	117	125	255	184	231	197	287	242	246	266	301	288
Education, training, employment, & soc. svcs.	61	66	78	70	77	86	83	78	83	92	106	115	118	120	120
Commerce and housing credit	15	17	17	19	20	23	26	26	28	29	31	39	35	36	40
Veterans benefits and services	14	15	13	14	15	15	15	17	17	16	16	16	16	13	11
Administration of justice	9	5	4	4	5	4	5	8	8	7	9	6	5	3	3
Community and regional development	8	5	7	6	5	6	6	4	7	3	3	10	11	11	0
General government	*	3	2	3	3	4	5	4	5	3	3	0	0	0	0
International affairs	0	12	10	10	3	4	5	3	3	3	4	6	6	7	6
Income security	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0
	Millions of constant 1987 dollars[1]														
Total	6,680	6,564	6,346	7,180	7,780	8,282	8,438	9,021	9,221	9,841	10,016	10,621	10,802	10,973	10,921
Health	2,494	2,508	2,336	2,845	3,095	3,439	3,423	3,851	3,945	4,079	4,136	4,299	4,585	4,624	4,585
General science	1,632	1,614	1,550	1,654	1,767	1,887	1,849	1,942	1,989	2,093	2,046	2,163	2,108	2,095	2,238
Space research and technology	683	572	519	576	711	528	759	843	911	1,016	1,232	1,266	1,248	1,292	1,216
National defense	782	784	833	906	930	908	989	900	874	892	855	1,017	955	1,080	996
Energy	283	283	311	368	402	454	470	511	551	650	675	752	767	751	782
Agriculture	348	361	353	375	388	431	402	397	413	400	405	416	440	428	436
Natural resources and environment	193	168	166	179	211	218	210	206	203	306	298	333	319	304	297
Transportation	112	114	122	134	138	270	189	231	190	265	215	211	221	245	229
Education, training, employment, & soc. svcs.	86	85	93	80	85	91	85	78	80	85	94	98	98	98	95
Commerce and housing credit	21	22	20	22	22	24	27	26	27	27	28	33	29	29	32
Veterans benefits and services	20	19	16	16	17	16	15	17	16	15	14	14	13	11	9
Administration of justice	13	6	5	5	6	4	5	8	8	6	8	5	4	2	2
Community and regional development	11	6	8	7	6	6	6	4	7	3	3	9	9	9	0
General government	*	4	2	3	3	4	5	4	5	3	3	0	0	0	0
International affairs	0	15	12	11	3	4	5	3	3	3	4	5	5	6	5
Income security	1	4	0	0	0	0	0	0	0	0	0	0	0	0	0

* = Less than $500,000

NOTE: Data for 1980–92 are actual budget authority. Data for 1993 and 1994 are estimates based on the FY 1994 budget.

[1] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resource Studies Division, National Science Foundation, *Selected Data on Federal R&D Funding by Budget Function: Fiscal Years 1992–94*, NSF 93-311 (Washington, DC: NSF, 1993).

See figure 4–10.

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Appendix table 4-28.

National support for health R&D, by performer and source of funds: 1980–92

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991 (est)	1992 (est.)
Millions of current dollars													
Source of funds													
Government	5,203	5,413	5,612	6,117	6,887	7,675	7,929	9,037	9,725	10,634	11,422	12,413	13,424
Federal	4,723	4,848	4,970	5,399	6,087	6,791	6,895	7,847	8,425	9,163	9,791	10,711	11,596
Nat'l Institutes of Health	3,182	3,333	3,433	3,789	4,257	4,828	5,005	5,852	6,292	6,778	7,136	7,711	8,423
State and local	480	564	642	718	800	884	1,034	1,191	1,300	1,471	1,632	1,702	1,827
Industry	2,459	2,998	3,593	4,205	4,765	5,352	6,188	7,103	8,432	9,404	10,634	12,020	13,505
Private nonprofit	305	328	390	456	507	538	782	800	854	939	1,020	1,128	1,196
Howard Hughes[1]	18	20	25	54	79	51	247	183	179	197	215	250	281
Performer													
Government	1,487	1,575	1,669	1,813	1,997	2,140	2,155	2,389	2,590	2,578	2,861	3,300	3,568
Federal	1,284	1,364	1,448	1,577	1,741	1,869	1,848	2,042	2,213	2,161	2,403	2,816	3,049
State and local	203	211	221	236	256	271	307	347	377	417	458	484	520
Industry[2]	2,249	2,659	3,161	3,668	4,216	4,660	5,293	6,002	6,927	7,901	8,817	9,578	11,006
Higher education[2]	3,005	3,211	3,388	3,779	4,274	4,745	5,320	5,056	6,593	7,238	7,744	8,467	9,173
Private nonprofit[2]	726	751	785	887	976	1,115	1,157	1,352	1,455	1,798	1,886	1,931	2,087
Foreign	499	543	593	631	697	805	975	1,140	1,446	1,462	1,769	2,078	2,291
Biomedical R&D price index[3]	0.649	0.713	0.774	0.819	0.867	0.911	0.949	1.000	1.050	1.106	1.166	1.224	1.284
Millions of constant 1987 dollars													
Total	12,276	12,255	12,397	13,160	14,024	14,890	15,701	16,940	18,106	18,967	19,791	20,882	21,904
Source of funds													
Government	8,017	7,591	7,251	7,469	7,943	8,424	8,355	9,037	9,262	9,615	9,796	10,141	10,455
Federal	7,277	6,800	6,421	6,593	7,021	7,454	7,266	7,847	8,024	8,285	8,397	8,751	9,031
Nat'l Institutes of Health	4,903	4,675	4,435	4,626	4,910	5,300	5,274	5,852	5,992	6,128	6,120	6,300	6,560
State and local	740	791	829	877	923	970	1,090	1,191	1,238	1,330	1,400	1,391	1,423
Industry	3,788	4,205	4,642	5,134	5,496	5,875	6,521	7,103	8,030	8,503	9,120	9,820	10,518
Private nonprofit	470	460	504	557	585	591	824	800	813	849	875	922	931
Howard Hughes[1]	8	28	32	66	91	56	260	183	170	178	184	204	219
Performer													
Government	2,292	2,208	2,156	2,214	2,303	2,349	2,271	2,389	2,467	2,331	2,454	2,696	2,779
Federal	1,979	1,912	1,871	1,925	2,008	2,052	1,947	2,042	2,108	1,954	2,061	2,301	2,375
State and local	313	296	286	288	295	297	323	347	359	377	393	395	405
Industry	3,466	3,729	4,084	4,479	4,863	5,115	5,577	6,002	6,597	7,144	7,562	7,825	8,572
Higher education	4,630	4,504	4,377	4,614	4,930	5,209	5,606	5,056	6,279	6,544	6,642	6,917	7,144
Private nonprofit	1,119	1,053	1,014	1,083	1,126	1,224	1,219	1,352	1,386	1,626	1,617	1,578	1,625
Foreign	768	762	766	770	804	884	1,027	1,140	1,377	1,322	1,517	1,698	1,784

[1] For Howard Hughes Medical Institute, figures are for the direct conduct of biomedical research, and exclude support for scientific career development. Figures for 1985 include only 8 months of operations because of change in fiscal year.

[2] Includes expenditures for federally funded research and development centers administered by organizations in the respective sectors.

[3] The biomedical R&D price index used here differs from the GDP implicit price deflator detailed in appendix table 4-1.

SOURCE: National Institutes of Health, Department of Health and Human Services, *NIH Data Book* (Bethesda, MD: NIH, annual series).

See figure 4-11.

Appendix table 4–29.
Indicators of technology transfer from federal laboratories: 1987–91
(page 1 of 2)

Agency	1987	1988	1989	1990	1991
Number of active cooperative R&D agreements					
Total, all agencies	108	194	403	607	975
Dept. of Agriculture	9	51	98	128	177
Dept. of Commerce	0	9	44	82	115
Dept. of Defense					
Air Force	0	2	7	13	26
Army	2	9	32	80	115
Navy	0	0	2	20	52
Dept. of Energy	0	0	0	1	43
Environmental Protection Agency	0	0	2	11	31
Dept. of Health and Human Services	22	28	89	110	144
Dept. of the Interior	0	0	1	12	11
National Aeronautics & Space Admin.[1]	75	95	127	147	244
Dept. of Transportation	0	0	0	1	9
Dept. of Veterans Affairs	0	0	1	2	8
Number of inventions disclosed					
Total, all agencies	2,662	3,047	3,168	3,772	4,213
Dept. of Agriculture	83	144	127	158	127
Dept. of Commerce	43	31	49	46	30
Dept. of Defense					
Air Force	83	90	169	160	102
Army	248	348	276	376	463
Navy	622	709	708	847	959
Dept. of Energy	857	1,003	1,053	1,335	1,666
Environmental Protection Agency	0	0	0	12	20
Dept. of Health and Human Services	194	226	209	215	215
Dept. of the Interior	3	6	3	26	26
National Aeronautics & Space Admin.	496	462	532	538	570
Dept. of Transportation	0	0	0	1	2
Dept. of Veterans Affairs	33	28	42	58	33
Number of patent applications					
Total, all agencies	848	1,131	1,462	1,669	1,936
Dept. of Agriculture	44	50	71	76	110
Dept. of Commerce	8	15	28	28	18
Dept. of Defense					
Air Force	49	47	122	145	178
Army	177	203	216	236	274
Navy	117	197	278	426	467
Dept. of Energy	252	336	382	366	397
Environmental Protection Agency	4	5	5	6	8
Dept. of Health and Human Services	98	145	225	239	261
Dept. of the Interior	5	4	11	15	21
National Aeronautics & Space Admin.	94	129	121	123	201
Dept. of Transportation	0	0	0	1	1
Dept. of Veterans Affairs	NA	NA	3	8	NA

(continued)

Appendix table 4–29.

Indicators of technology transfer from federal laboratories: 1987–91

(page 2 of 2)

Agency	1987	1988	1989	1990	1991
	Number of licenses granted				
Total, all agencies	128	125	157	193	261
Exclusive	53	60	76	83	100
Nonexclusive	75	65	81	110	161
Dept. of Agriculture	30	24	23	33	29
Dept. of Commerce	0	0	1	0	2
Dept. of Defense					
Air Force	1	2	2	4	1
Army	3	2	2	3	9
Navy	6	2	10	8	15
Dept. of Energy	37	43	57	88	125
Environmental Protection Agency	0	0	0	1	2
Dept. of Health and Human Services	35	42	48	47	69
Dept. of the Interior	3	3	7	3	5
National Aeronautics & Space Admin.	13	7	7	6	4

NA = not available

[1] Cooperative agreements made by National Aeronautics and Space Administration labs are made under the authority of the 1958 Space Act.

SOURCE: Office of Technology Commercialization, Department of Commerce, *Technology Transfer Under the Stevenson-Wydler Technology Innovation Act: The Second Biennial Report* (Washington, DC: DOC, January 1993).

See figure 4–24.

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Appendix table 4–30.

Industrial R&D, by character of work, industry classification, and source of funds: 1991

Industry	SIC code	Total			Basic			Applied			Development		
		Total	Federal	Other	Total	Federal	Other	Total	Federal	Other	Total	Federal	Other
		Millions of dollars											
Total		102,246	25,308	76,938	4,372	1,148	3,225	24,084	4,918	19,166	73,789	19,242	54,547
Food, kindred, and tobacco products	20,21	1,360	0	1,360	154	0	154	471	0	471	735	0	734
Textiles and apparel	22,23	D	D	215	D	0	D	S	0	S	138	D	D
Lumber, wood products, and furniture	24,25	160	0	160	D	0	D	60	0	60	D	0	D
Paper and allied products	26	715	0	715	D	0	D	186	0	186	D	0	D
Chemicals and allied products	28	13,183	89	13,094	835	6	829	5,338	17	5,321	7,011	S	6,945
Industrial chemicals	281-82,286	4,433	83	4,350	323	6	317	D	D	1,929	D	D	S
Drugs and medicines	283	D	D	6,098	S	0	S	D	D	2,610	3,077	1	3,076
Other chemicals	284-85,287-89	D	D	2,646	99	0	99	D	D	782	D	D	1,765
Petroleum refining and extraction	13,29	2,245	10	2,235	D	D	154	D	D	873	D	D	1,208
Rubber products	30	D	D	694	S	0	S	D	D	225	D	D	415
Stone, clay, and glass products	32	D	D	895	D	D	182	D	D	444	D	D	268
Primary metals	33	836	17	819	S	0	S	D	D	(S)	D	D	437
Fabricated metal products	34	756	130	626	19	0	19	D	D	138	D	D	469
Machinery	35	15,089	1,055	14,034	D	D	296	D	D	2,383	D	D	11,354
Office, computing, & acctg. machines	357	D	D	10,527	D	D	167	D	D	1,748	D	D	8,612
Other machinery, except electrical	351-56,358-59	D	D	3,507	D	D	130	D	D	635	D	D	2,742
Electrical equipment	36	17,279	4,824	12,455	504	9	495	4,512	1,369	3,143	12,264	3,446	8,818
Radio and TV receiving equipment	365	78	0	78	D	0	D	D	0	D	S	0	S
Communication equipment	366	10,444	4,212	6,232	D	D	D	D	D	D	8,158	3,082	5,076
Electronic components	367	5,321	595	4,726	D	D	107	D	D	1,757	3,209	347	2,862
Other electrical equipment	361-64,369	1,436	17	1,419	79	0	79	523	0	523	835	S	S
Transportation equipment	37	32,091	16,217	15,874	657	470	187	4,413	2,139	2,274	27,021	13,608	13,413
Motor vehicles & motor veh. eqpt.	371	D	D	8,998	87	0	87	D	D	D	D	D	D
Other transportation equipment	373-75,379	D	D	288	11	0	11	D	D	D	D	D	D
Aircraft and missiles	372,376	21,692	15,104	6,588	559	471	89	3,248	1,731	1,517	17,884	12,902	4,982
Professional and scientific instruments	38	6,621	100	6,521	D	D	382	1,461	20	1,441	D	D	4,699
Scientific & mech. measuring inst.	381-82	2,150	S	2,143	D	D	43	D	D	S	D	D	1,710
Optical, surg., photog., & other inst.	383-87	4,471	93	4,378	D	D	293	D	D	1,050	D	D	3,035
Other manufacturing industries	27,31,39	D	D	414	19	0	19	D	D	67	D	D	327
Nonmanufacturing industries	10-11,14-17,40-42,44-51,53-54,56,60,62-63,72-73,78,806-07,87	9,642	2,815	6,827	937	607	330	2,599	823	1,777	6,106	1,386	4,720

D = withheld to avoid disclosing operations of individual companies; S = withheld because of imputation of more than 50 percent; SIC = standard industrial classification

SOURCE: Science Resources Studies Division, National Science Foundation, *Research and Development in Industry: 1991* (Washington, DC: NSF, forthcoming).

Appendix table 4–31.

Total expenditures for industrial R&D (financed by company, federal, and other funds), by industry and size of company: 1980–91

(page 1 of 2)

Industry and size of company	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Millions of dollars											
Total	44,505	51,810	58,650	65,268	74,800	84,239	87,823	92,155	97,889	101,854	104,606	102,246
Food, kindred, and tobacco products	620	D	D	D	D	D	D	1,206	D	D	D	1,360
Textiles and apparel	115	D	D	D	D	D	D	D	D	D	D	D
Lumber, wood products, and furniture	148	161	159	152	143	147	144	137	D	172	183	160
Paper and allied products	495	D	566	D	D	D	D	D	D	686	730	715
Chemicals and allied products	4,636	5,625	6,604	7,185	7,927	8,540	8,843	9,635	10,772	11,466	12,344	13,183
Industrial chemicals	2,197	2,802	3,206	3,214	3,240	3,498	3,552	3,716	3,959	4,039	4,337	4,433
Drugs and medicines	1,777	D	D	D	D	D	3,658	D	4,746	D	D	D
Other chemicals	662	D	D	D	D	D	1,633	D	2,067	D	D	D
Petroleum refining and extraction	1,552	D	D	D	D	D	D	1,897	1,944	2,066	2,129	2,245
Rubber products	656	D	D	D	D	D	D	D	D	D	D	D
Stone, clay, and glass products	406	D	D	D	D	D	950	995	D	D	D	D
Primary metals	728	878	987	1,085	D	D	D	730	663	749	D	836
Ferrous metals and products	443	D	D	D	D	D	D	D	258	D	D	D
Nonferrous metals and products	285	D	D	D	336	416	458	D	405	D	D	D
Fabricated metal products	550	624	625	701	842	829	895	783	829	800	778	756
Machinery	5,901	6,818	8,078	9,027	10,504	12,216	D	D	D	14,635	14,696	15,089
Office, computing, and accounting machines	3,962	D	D	D	D	D	D	D	D	D	D	D
Other machinery, except electrical	1,939	D	D	D	D	D	2,396	2,428	2,719	D	D	D
Electrical equipment	9,175	10,329	10,923	12,681	13,778	14,432	14,980	15,848	16,242	16,929	17,723	17,279
Radio and TV receiving equipment	556	D	D	D	D	D	133	139	139	84	93	78
Communication equipment	4,024	4,758	5,839	7,298	8,685	9,397	9,669	10,184	10,296	10,539	10,770	10,444
Electronic components	1,547	1,573	1,740	2,169	2,831	3,385	D	4,286	4,607	4,990	5,432	5,321
Other electrical equipment	3,048	D	D	D	D	D	D	1,239	1,200	1,316	1,428	1,436
Transportation equipment	14,315	D	D	D	D	D	31,275	34,246	36,338	36,844	36,019	32,091
Motor vehicles and motor vehicles equipment	4,955	4,806	4,797	5,318	6,057	6,984	D	D	D	D	D	D
Other transportation equipment	162	D	D	D	D	D	D	D	D	D	D	D
Aircraft and missiles	9,198	11,968	14,451	15,406	18,858	22,231	21,050	24,458	25,900	25,638	25,356	21,692
Professional and scientific instruments	3,029	3,614	3,930	4,266	4,602	5,013	5,103	5,222	5,426	5,743	6,194	6,621
Scientific and mechanical measuring instruments	1,352	D	D	D	D	D	D	D	1,734	1,868	2,096	2,150
Optical, surgical, photographic, and other inst.	1,677	D	D	D	D	D	D	D	3,692	3,875	4,098	4,471
Other manufacturing industries	364	D	D	D	D	D	D	D	D	D	D	D
Nonmanufacturing industries	1,815	1,906	2,472	3,337	4,905	6,714	7,446	7,844	8,113	8,286	9,274	9,642

(continued)

Appendix table 4-31.

Total expenditures for industrial R&D (financed by company, federal, and other funds), by industry and size of company: 1980–91

(page 2 of 2)

Industry and size of company	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Millions of dollars											
Less than 500 employees[1]	2,065	2,305	2,934	4,422	4,402	5,866	7,071	7,163	7,249	7,620	8,231	8,786
500 to 999[1]	NA	NA	NA	NA	1,439	1,648	1,902	1,725	1,656	1,765	1,976	1,947
1,000 to 4,999	2,701	3,148	3,864	4,178	5,520	6,240	7,472	7,262	7,598	7,696	7,786	8,056
5,000 to 9,999	2,028	2,988	2,751	2,798	3,251	4,022	4,251	4,501	5,236	5,626	6,163	6,593
10,000 to 24,999	6,017	6,762	7,943	9,499	11,351	11,109	10,493	12,043	11,473	10,185	11,598	13,361
25,000 or more	31,693	36,607	41,156	44,372	48,837	55,354	56,991	59,461	64,677	68,962	68,852	63,503

D = withheld to avoid disclosing operations of individual companies; NA = not available

[1] Until 1984, data represent companies with less than 1,000 employees.

SOURCE: Science Resources Studies Division, National Science Foundation, *Research and Development in Industry: 1991* (Washington, DC: NSF, forthcoming).

See figure 4-23.

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Appendix table 4–32.

Company and other (except federal) funds for industrial R&D performance, by industry and size of company: 1980–91
(page 1 of 2)

Industry and size of company	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Millions of dollars											
Total	30,476	35,428	40,105	44,588	51,404	57,043	59,932	61,403	65,772	70,562	73,980	76,938
Food, kindred, and tobacco products	D	636	777	824	1,081	1,136	1,280	1,204	1,192	1,284	1,308	1,360
Textiles and apparel	D	116	136	150	182	218	246	243	210	S	242	215
Lumber, wood products, and furniture	D	161	159	152	143	147	144	137	156	172	183	160
Paper and allied products	D	566	566	552	594	576	538	604	664	686	730	715
Chemicals and allied products	4,264	5,205	6,197	6,792	7,736	8,310	8,664	9,445	10,573	11,383	12,277	13,094
Industrial chemicals	1,856	2,393	2,810	2,828	3,057	3,281	3,374	3,531	3,763	3,960	4,272	4,350
Drugs and medicines	D	2,064	2,473	2,896	3,310	3,481	3,657	4,095	4,743	5,164	5,366	6,098
Other chemicals	653	747	914	1,068	1,369	1,548	1,633	1,819	2,067	2,259	2,638	2,646
Petroleum refining and extraction	1,401	1,780	2,003	2,074	2,245	2,194	1,971	1,883	1,923	2,050	2,113	2,235
Rubber products	D	598	617	638	671	659	655	596	635	678	730	694
Stone, clay, and glass products	D	411	472	586	705	825	941	985	826	863	894	895
Primary metals	594	702	711	701	683	730	786	711	642	715	801	819
Ferrous metals and products	338	415	426	396	357	323	336	249	257	254	245	244
Nonferrous metals and products	256	287	285	305	326	407	450	462	385	461	556	575
Fabricated metal products	501	545	565	634	773	780	800	633	687	664	644	626
Machinery	5,254	6,124	7,227	7,911	9,312	10,721	10,701	10,577	11,992	13,478	13,780	14,034
Office, computing, and accounting machines	D	3,847	4,944	5,634	7,011	8,418	8,380	8,193	9,371	10,780	11,073	10,527
Other machinery, except electrical	D	2,277	2,283	2,277	2,301	2,303	2,321	2,384	2,621	2,698	2,707	3,507
Electrical equipment	5,431	6,409	6,682	8,158	9,037	9,271	9,767	10,449	11,061	11,641	12,131	12,455
Radio and TV receiving equipment	346	358	364	324	362	350	133	139	139	84	93	78
Communication equipment	2,367	2,975	3,555	4,500	5,147	5,174	5,117	5,455	5,675	5,820	5,932	6,232
Electronic components	1,165	1,212	1,342	1,810	2,354	2,826	3,357	3,630	4,068	4,458	4,709	4,726
Other electrical equipment	1,553	1,864	1,421	1,524	1,174	921	1,160	1,225	1,179	1,279	1,397	1,419
Transportation equipment	6,958	7,739	8,621	8,991	10,406	12,092	13,567	13,462	14,162	15,083	14,992	15,874
Motor vehicles and motor vehicles equipment	4,300	4,219	4,321	4,754	5,384	6,164	7,171	7,167	7,769	8,725	8,548	8,998
Other transportation equipment	D	80	114	227	258	279	330	356	370	353	304	288
Aircraft and missiles	2,570	3,440	4,186	4,010	4,764	5,649	6,066	5,939	6,023	6,005	6,140	6,588
Professional and scientific instruments	2,456	2,978	3,407	3,816	4,211	4,622	4,752	4,950	5,306	5,630	6,095	6,521
Scientific and mechanical measuring instruments	1,001	1,235	1,363	1,605	1,671	1,596	1,521	1,598	1,710	1,858	2,086	2,143
Optical, surgical, photographic, and other inst.	1,454	1,743	2,044	2,211	2,540	3,026	3,231	3,352	3,596	3,772	4,009	4,378
Other manufacturing industries	339	411	493	525	373	361	380	380	383	400	472	414
Nonmanufacturing industries	1,037	1,048	1,472	2,084	3,252	4,401	4,740	5,144	5,360	5,620	6,588	6,827

(continued)

Appendix table 4–32.

Company and other (except federal) funds for industrial R&D performance, by industry and size of company: 1980–91

(page 2 of 2)

Industry and size of company	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Millions of dollars											
Less than 500 employees[1]	1,711	1,880	2,411	3,781	3,781	5,127	6,203	6,200	6,386	6,633	7,256	7,858
500 to 999[1]	N/A	N/A	N/A	N/A	1,341	1,531	1,765	1,610	1,517	1,660	1,836	1,711
1,000 to 4,999	2,257	2,586	3,241	3,438	4,618	5,249	6,243	6,281	6,441	6,646	6,827	7,125
5,000 to 9,999	1,596	2,369	2,224	2,080	2,764	3,350	3,455	3,753	4,322	4,815	5,883	6,439
10,000 to 24,999	4,867	5,537	6,448	7,228	8,546	8,366	8,489	9,681	9,668	8,948	9,936	11,633
25,000 or more	20,045	23,056	25,781	28,061	30,354	33,421	33,778	33,878	37,438	41,860	42,242	42,172

D = withheld to avoid disclosing operations of individual companies; NA = not available; S = withheld because of imputation of more than 50 percent

[1] Until 1984, data represent companies with less than 1,000 employees.

SOURCE: Science Resources Studies Division, National Science Foundation, *Research and Development in Industry: 1991* (Washington, DC: NSF, forthcoming).

See figure 4–23.

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Appendix table 4–33.

Federal funds for industrial R&D performance, by industry and size of company: 1980–91

(page 1 of 2)

Industry and size of company	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Millions of dollars											
Total	14,029	16,382	18,545	20,680	23,396	27,196	27,891	30,752	32,117	31,292	30,626	25,308
Food, kindred, and tobacco products	D	D	D	D	D	D	D	2	D	D	D	0
Textiles and apparel	D	D	D	D	D	D	D	D	D	D	D	D
Lumber, wood products, and furniture	D	0	0	0	0	0	0	0	0	0	0	0
Paper and allied products	D	D	0	D	D	D	D	D	D	0	0	0
Chemicals and allied products	372	421	407	393	191	230	179	190	199	83	67	89
Industrial chemicals	341	409	396	386	183	217	178	185	196	79	65	83
Drugs and medicines	D	D	D	D	D	D	1	D	3	D	D	D
Other chemicals	D	D	D	D	D	D	0	D	0	D	D	D
Petroleum refining and extraction	151	D	D	D	D	D	D	14	21	S	S	10
Rubber products	D	D	D	D	D	D	D	D	D	D	D	D
Stone, clay, and glass products	D	D	D	D	D	D	9	10	D	D	D	D
Primary metals	135	176	276	384	D	D	D	19	21	34	D	17
Ferrous metals and products	105	D	D	D	D	D	D	D	1	D	D	D
Nonferrous metals and products	30	D	D	D	10	9	8	D	20	D	D	D
Fabricated metal products	49	80	60	67	69	49	95	150	142	135	134	130
Machinery	647	694	851	1,116	1,192	1,495	D	D	D	1,157	916	1,055
Office, computing, and accounting machines	D	D	D	D	D	D	D	D	D	D	D	D
Other machinery, except electrical	D	D	D	D	D	D	75	44	98	D	D	D
Electrical equipment	3,744	3,920	4,241	4,523	4,741	5,161	5,213	5,399	5,181	5,288	5,592	4,824
Radio and TV receiving equipment	210	D	D	D	D	D	0	0	0	0	0	0
Communication equipment	1,657	1,783	2,284	2,798	3,538	4,223	4,552	4,729	4,621	4,719	4,838	4,212
Electronic components	382	361	398	359	477	559	D	656	539	532	723	595
Other electrical equipment	1,495	D	D	D	D	D	D	14	21	37	31	17
Transportation equipment	D	D	D	D	D	D	17,708	20,784	22,176	21,761	21,027	16,217
Motor vehicles and motor vehicles equipment	655	587	476	564	673	820	D	D	D	D	D	D
Other transportation equipment	D	D	D	D	D	D	D	D	D	D	D	D
Aircraft and missiles	6,628	8,528	10,265	11,396	14,094	16,582	14,984	18,519	19,877	19,633	19,216	15,104
Professional and scientific instruments	573	637	523	450	391	391	351	272	120	113	99	100
Scientific and mechanical measuring instruments	350	D	D	D	D	D	D	D	S	S	S	S
Optical, surgical, photographic, and other inst.	223	D	D	D	D	D	D	D	96	103	89	93
Other manufacturing industries	25	D	D	D	D	D	2	D	D	D	D	D
Nonmanufacturing industries	779	858	1,000	1,253	1,653	2,313	2,706	2,700	2,753	2,666	2,686	2,815

(continued)

Appendix table 4–33.

Federal funds for industrial R&D performance, by industry and size of company: 1980–91

(page 2 of 2)

Industry and size of company	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Millions of dollars											
Less than 500 employees[1]	354	424	523	641	621	739	868	963	864	987	975	928
500 to 999[1]	N/A	N/A	N/A	N/A	98	117	137	115	139	105	140	236
1,000 to 4,999	444	562	623	740	902	991	1,229	981	1,157	1,050	959	931
5,000 to 9,999	432	619	527	718	487	672	796	748	914	811	280	154
10,000 to 24,999	1,150	1,225	1,495	2,271	2,805	2,743	2,004	2,362	1,805	1,237	1,662	1,728
25,000 or more	11,648	13,551	15,377	16,311	18,483	21,933	23,213	25,583	27,239	27,102	26,610	21,331

D = withheld to avoid disclosing operations of individual companies; NA = not available; S = withheld because of imputation of more than 50 percent

[1] Until 1984, data represent companies with less than 1,000 employees.

SOURCE: Science Resources Studies Division, National Science Foundation, *Research and Development in Industry: 1991* (Washington, DC: NSF, forthcoming).

See figure 4–23.

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Appendix table 4–34.

Industrial nonmanufacturing R&D performance, by industry and source of funds: 1989–91

Industry	SIC code	1989			1990			1991		
		Total	Company	Federal	Total	Company	Federal	Total	Company	Federal
		Millions of dollars								
Total R&D performance		8,286	5,620	2,666	9,274	6,588	2,686	9,642	6,827	2,815
Communication services	48, part 737	D	249	D	D	623	D	D	557	D
Electric, gas, and sanitary services	49	234	213	21	244	227	15	278	259	19
Computer programming, data processing, other computer-related engineering, architectural, and surveying services	part 737, 871	3,784	2,421	1,363	4,629	3,140	1,489	4,784	3,234	1,550
Hospitals and medical and dental laboratories	806-07	163	160	3	192	189	3	229	227	2
Research, development, and testing services	873	1,405	855	550	1,335	920	415	1,347	975	372
Other nonmanufacturing industries	10-11,14-17,40-42,44-47,50-51,53-54,56,60,62-63,72-73,78,872, 874	D	1,722	D	D	1,487	D	D	1,574	D

D = withheld to avoid disclosing operations of individual companies; SIC = standard industrial classification

SOURCE: Science Resources Studies Division, National Science Foundation, *Research and Development in Industry: 1991* (Washington, DC: NSF, forthcoming).

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Appendix table 4–35.
International R&D expenditures and R&D as a percentage of GDP: 1970–91

	R&D expenditures[1]							R&D expenditures as a percentage of GDP						
	United States	Japan	Germany	France	United Kingdom	Italy	Canada	United States	Japan	Germany[2]	France	United Kingdom	Italy	Canada
	Billions of constant 1987 dollars							Percent						
1970	74.2	16.0	13.8	10.1	NA	3.9	2.7	2.6	1.8	2.1	1.9	NA	0.8	1.2
1971	71.9	17.1	15.2	10.5	NA	4.1	3.1	2.4	1.9	2.2	1.9	NA	0.9	1.3
1972	73.4	18.9	15.9	10.7	11.6	4.3	3.2	2.4	1.9	2.2	1.9	2.1	0.9	1.2
1973	74.4	20.7	15.8	10.7	NA	4.3	3.1	2.3	2.0	2.1	1.8	NA	0.8	1.1
1974	73.2	21.2	16.2	11.2	NA	4.2	3.1	2.3	2.0	2.1	1.8	NA	0.8	1.1
1975	71.6	21.6	16.7	11.3	12.2	4.6	3.2	2.2	2.1	2.2	1.8	2.0	0.8	1.1
1976	74.6	22.4	17.0	11.5	NA	4.5	3.2	2.2	2.0	2.2	1.8	NA	0.8	1.0
1977	76.5	23.1	17.4	11.8	NA	4.7	3.4	2.2	2.0	2.2	1.7	NA	0.8	1.1
1978	79.8	24.2	18.7	12.1	13.5	4.6	3.6	2.2	2.0	2.3	1.7	2.1	0.7	1.1
1979	83.8	26.8	20.5	12.9	NA	4.9	3.8	2.2	2.1	2.4	1.8	NA	0.7	1.1
1980	87.3	29.3	21.4	13.3	NA	5.1	4.0	2.3	2.2	2.4	1.8	NA	0.7	1.1
1981	91.1	32.0	21.1	14.6	15.4	6.0	4.5	2.4	2.3	2.4	2.0	2.4	0.9	1.2
1982	95.5	34.4	21.8	15.6	NA	6.2	4.9	2.5	2.4	2.5	2.1	NA	0.9	1.4
1983	102.2	37.1	21.9	16.0	15.0	6.6	4.9	2.6	2.5	2.5	2.1	2.2	1.0	1.4
1984	111.1	39.6	22.4	16.8	NA	7.1	5.3	2.7	2.6	2.5	2.2	NA	1.0	1.4
1985	120.6	43.5	24.4	17.3	15.8	8.1	5.7	2.8	2.7	2.7	2.3	2.3	1.1	1.4
1986	123.4	43.9	24.9	17.5	16.8	8.3	6.0	2.8	2.7	2.7	2.2	2.3	1.1	1.5
1987	125.4	46.9	26.5	18.1	16.9	9.0	6.0	2.8	2.8	2.9	2.3	2.2	1.2	1.4
1988	128.7	50.2	27.2	18.8	17.4	9.5	6.1	2.7	2.9	2.9	2.3	2.2	1.2	1.4
1989	129.7	54.5	28.2	19.9	18.0	10.0	6.1	2.7	3.0	2.9	2.3	2.2	1.2	1.4
1990	129.4	59.1	28.0	21.1	17.6	10.6	6.4	2.7	3.1	2.7	2.4	2.2	1.3	1.4
1991	123.4	60.7	29.6	21.3	16.3	11.4	6.4	2.6	3.0	2.8	2.4	2.1	1.4	1.4

NA = Not available

[1] Conversions of foreign currencies to U.S. dollars are calculated with Organisation for Economic Co-operation and Development purchasing power parity exchange rates. (See appendix table 4-2.) Constant 1987 dollars are based on the U.S. Department of Commerce calendar year GDP implicit price deflators. (See appendix table 4-1.)

[2] German data are for the former West Germany only. The R&D/GDP ratio for the unified Germany was 2.6 percent in 1991.

SOURCES: Science Resources Studies Division, National Science Foundation *International Science and Technology Update* (Washington, DC: NSF, periodic series); Organisation for Economic Co-operation and Development Main Science and Technology Indicators database; and national sources.

See figure 4–7. *Science & Engineering Indicators – 1993*

Appendix table 4–36.

International nondefense R&D expenditures and nondefense R&D as a percentage of GDP: 1970–91

	Nondefense R&D expenditures[1]							Nondefense R&D expenditures as a percentage of GDP						
	United States	Japan	Germany[2]	France	United Kingdom	Italy	Canada	United States	Japan	Germany[2]	France	United Kingdom	Italy	Canada
	Billions of constant 1987 dollars							Percent						
1970	51.6	NA	12.6	NA	NA	3.9	NA	1.8	NA	1.9	NA	NA	0.8	NA
1971	50.0	16.9	14.1	8.0	NA	4.0	2.9	1.7	1.9	2.0	1.4	NA	0.8	1.2
1972	50.4	18.7	15.0	8.4	8.5	4.2	3.1	1.6	1.9	2.1	1.5	1.5	0.8	1.2
1973	52.6	20.5	14.7	8.4	NA	4.2	3.0	1.6	2.0	1.9	1.4	NA	0.8	1.1
1974	53.1	21.0	15.1	8.9	NA	4.1	3.0	1.6	2.0	2.0	1.4	NA	0.8	1.1
1975	51.9	21.5	15.7	9.1	8.5	4.6	3.1	1.6	2.1	2.1	1.4	1.4	0.8	1.1
1976	54.7	22.3	15.9	9.4	NA	4.4	3.1	1.6	2.0	2.0	1.4	NA	0.8	1.0
1977	55.3	23.0	16.4	9.6	NA	4.7	3.3	1.6	2.0	2.0	1.4	NA	0.8	1.0
1978	58.4	24.1	17.6	9.7	9.6	4.5	3.5	1.6	2.0	2.1	1.4	1.5	0.7	1.0
1979	62.7	26.6	19.3	10.1	NA	4.8	3.7	1.7	2.1	2.2	1.4	NA	0.7	1.1
1980	66.5	29.1	20.4	10.3	NA	5.1	3.9	1.8	2.2	2.3	1.4	NA	0.7	1.1
1981	67.8	31.8	20.2	10.9	11.4	5.8	4.4	1.8	2.3	2.3	1.5	1.8	0.8	1.2
1982	69.2	34.3	20.9	12.0	NA	6.1	4.7	1.8	2.4	2.4	1.6	NA	0.9	1.3
1983	73.6	36.9	21.0	12.6	11.1	6.4	4.8	1.9	2.5	2.4	1.7	1.7	0.9	1.3
1984	79.0	39.4	21.4	13.3	NA	6.8	5.1	1.9	2.6	2.4	1.7	NA	1.0	1.3
1985	84.9	43.2	23.2	13.7	11.8	7.6	5.5	2.0	2.8	2.6	1.8	1.7	1.1	1.4
1986	85.2	43.6	23.6	13.7	13.0	7.9	5.8	1.9	2.7	2.6	1.8	1.8	1.1	1.4
1987	86.2	46.6	25.2	14.2	13.3	8.6	5.8	1.9	2.8	2.7	1.8	1.8	1.1	1.4
1988	90.1	49.8	26.0	14.6	14.1	8.9	5.9	1.9	2.8	2.7	1.8	1.8	1.1	1.3
1989	92.3	54.1	26.8	15.6	14.4	9.3	5.9	1.9	3.0	2.7	1.8	1.8	1.2	1.3
1990	94.1	58.6	26.6	16.1	14.5	10.2	6.2	1.9	3.0	2.6	1.9	1.8	1.3	1.4
1991	90.0	60.2	28.3	16.6	13.2	10.9	6.2	1.9	3.0	2.7	1.9	1.7	1.3	1.4

NA = Not available

[1] Nondefense R&D expenditures are total R&D expenditures—generally as reported by the R&D performers (see appendix table 4–35)—minus goverment R&D funds for defense purposes (see appendix table 4–39)—generally taken from national budget documents; that is, as reported by the R&D funders. Conversions of foreign currencies to U.S. dollars are calculated with Organisation for Economic Co-operation and Development purchasing power parity exchange rates. (See appendix table 4-2.) Constant 1987 dollars are based on the U.S. Department of Commerce calendar year GDP implicit price deflators. (See appendix table 4-1.)

[2] German data are for the former West Germany only.

SOURCES: Science Resources Studies Division, National Science Foundation, *International Science and Technology Update* (Washington, DC: NSF, periodic series); Organisation for Economic Co-operation and Development Main Science and Technology Indicators database; and national sources.

See figures 4–7 and 4–8. *Science & Engineering Indicators – 1993*

Appendix table 4–37.
International R&D expenditures, by performing sector and source of funds: 1991

R&D performer	Total	Sources of R&D funds					Percent distribution, performers
		Industry	Government	Higher education	Private nonprofit	Foreign	
Japan (in billions of current yen)							
Total	13,769	10,005	2,546	1,116	91	12	100.0%
Industry	9,743	9,589	134	0	10	10	70.8
Government	1,047	23	1,023	0	0	0	7.6
Higher education	2,406	55	1,233	1,115	3	0	17.5
Private nonprofit	573	338	156	0	78	2	4.2
Percent distribution, sources	100.0%	72.7%	18.5%	8.1%	0.7%	0.1%	
Germany (in millions of current deutsche marks)							
Total	72,840	43,640	27,070	0	400	1.730	100.0%
Industry	49,850	42,580	5,510	—	160	1,600	68.4
Government	11,100	100	10,710	—	170	120	15.2
Higher education	11,560	900	10,660	—	—	—	15.9
Private nonprofit	330	60	190	—	70	10	0.5
Percent distribution, sources	100.0%	59.9%	37.2%	0.0%	0.5%	2.4%	
France (in millions of current francs)[1]							
Total	157,203	68,390	75,864	437	668	11,844	100.0%
Industry	94,997	65,631	18,765	9	32	10,560	60.4
Government	38,006	1,430	35,372	46	29	1,129	24.2
Higher education	22,905	1,112	21,281	359	18	135	14.6
Private nonprofit	1,295	217	446	23	589	20	0.8
Percent distribution, sources	100.0%	43.5%	48.3%	0.3%	0.4%	7.5%	
United Kingdom (in millions of current pounds)							
Total	11,940	5,980	4,120	90	360	1,390	100.0%
Industry	7,770	5,390	1,140	—	—	1,240	65.1
Government	1,640	190	1,360	—	60	30	13.7
Higher education	1,940	160	1,380	90	210	100	16.2
Private nonprofit	590	240	240	—	90	20	4.9
Percent distribution, sources	100.0%	50.1%	34.5%	0.8%	3.0%	11.6%	
Italy (in billions of current lire)							
Total	19,659	8,794	10,227	0	0	638	100.0%
Industry	10,968	8,614	1,792	—	—	562	55.8
Government	4,791	87	4,665	—	—	39	24.4
Higher education	3,900	93	3,770	—	—	37	19.8
Private nonprofit	—	—	—	—	—	—	0.0
Percent distribution, sources	100.0%	44.7%	52.0%	0.0%	0.0%	3.2%	
Canada (in millions of current dollars)							
Total	9,737	3,994	4,347	199	250	947	100.0%
Industry	5,184	3,795	471	—	—	918	53.2
Government	1,915	29	1,879	—	—	7	19.7
Higher education	2,527	158	1,955	199	202	13	26.0
Private nonprofit	111	12	42	—	48	9	1.1
Percent distribution, sources	100.0%	41.0%	44.6%	2.0%	2.6%	9.7%	

[1] Data for France are for 1990.

SOURCE: Organisation for Economic Co-operation and Development, unpublished tabulations.

See figure 4–5.

Appendix table 4–38.

R&D expenditures in the United States, by performing sector and domestic and foreign source of funds: 1980, 1987, and 1990

R&D performer	Total	Sources of R&D funds: Industry	Government	Higher education	Private nonprofit	Foreign	Percent distribution, performers
	Millions of dollars						
Total 1980 expenditures	62,610	29,395	29,461	1,334	903	1,517	100.0%
Industry	44,505	28,959	14,029	—	—	1,517	71.1
Government	7,632	—	7,632	—	—	—	12.2
Higher education	8,323	236	6,350	1,334	403	—	13.3
Other nonprofit	2,150	200	1,450	—	500	—	3.4
Percent distribution, sources	100.0%	46.9%	47.1%	2.1%	1.4%	2.4%	
Total 1987 expenditures	125,353	58,146	57,912	3,192	1,606	4,497	100.0%
Industry	92,155	56,906	30,752	—	—	4,497	73.5
Government	13,413	—	13,413	—	—	—	10.7
Higher education	16,360	790	11,547	3,192	831	—	13.1
Other nonprofit	3,425	450	2,200	—	775	—	2.7
Percent distribution, sources	100.0%	46.4%	46.2%	2.5%	1.3%	3.6%	
Total 1990 expenditures	146,434	67,311	63,996	4,356	2,368	8,403	100.0%
Industry	104,606	65,577	30,626	—	—	8,403	71.4
Government	16,002	—	16,002	—	—	—	10.9
Higher education	21,176	1,134	14,468	4,356	1,218	—	14.5
Other nonprofit	4,650	600	2,900	—	1,150	—	3.2
Percent distribution, sources	100.0%	46.0%	43.7%	3.0%	1.6%	5.7%	

NOTE: Foreign sources represent funding from companies located in the United States with foreign ownership of 50 percent or more.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *National Patterns of R&D Resources: 1992,* NSF 92-330 (Washington, DC: NSF, 1992); SRS, unpublished tabulations; and Bureau of Economic Analysis, unpublished tabulations.

See figure 4–5.

Appendix table 4–39.
Distribution of government R&D budget appropriations, by socioeconomic objective: 1992

Objective	United States	Japan	Germany	France	United Kingdom	Italy	Canada
	Percent						
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Agriculture, forestry, and fishing	2.2	3.6	2.7	4.0	4.0	2.6	12.6
Industrial development	0.3	3.9	13.3	12.6	7.9	14.3	9.9
Energy	4.5	21.3	4.7	3.1	2.0	3.7	5.8
Infrastructure	2.2	1.9	1.9	1.0	1.7	0.7	4.7
Transport and telecommunications	2.0	1.5	0.4	NA	NA	NA	3.5
Urban and rural planning	0.2	0.3	1.4	NA	NA	NA	1.1
Environmental protection	0.7	0.5	3.6	0.7	1.6	2.1	1.6
Health	14.7	0.5	3.6	0.7	1.6	2.1	1.6
Social development and services	1.3	2.9	3.3	3.4	6.0	6.2	7.9
Earth and atmosphere	1.2	1.0	2.6	0.4	2.4	4.8	2.4
Advancement of knowledge	3.9	50.8	48.1	26.9	22.5	46.3	36.3
Advancement of research	3.9	8.3	13.5	14.9	4.9	9.4	15.4
General university funds	—	42.5	34.6	12.0	17.6	36.9	20.8
Civil space	9.6	7.1	5.9	8.4	3.1	7.2	6.9
Defense	59.4	5.9	10.5	37.4	46.2	7.3	7.0
Not elsewhere classified	0.0	0.0	0.7	0.4	0.3	3.5	1.7

NA = not separately available but included in subtotal; — = the United States does not have an equivalent to Europe's and Japan's general university funds

NOTES: Percentages may not add to 100 because of rounding. U.S. data are based on budget authority. Because of general university funds and slight differences in accounting practices, the distribution of government budgets among socioeconomic objectives may not completely reflect the actual distribution of government-funded research in particular objectives. Japanese data are based on science and technology budget data, which include items other than R&D. Such items are a small proportion of the budget, and therefore the data may still be used as an approximate indicator of relative government emphasis on R&D by objective. Data for Canada and France are for 1991.

SOURCES: Science Resources Studies Division, National Science Foundation *International Science and Technology Update* (Washington, DC: NSF, annual series); Organisation for Economic Co-operation and Development Main Science and Technology Indicators database; and national sources.

See figure 4–12. *Science & Engineering Indicators – 1993*

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Appendix table 4–40.

Company-financed R&D performed abroad by U.S. companies and their foreign subsidiaries, by industry: 1980–91

(page 1 of 2)

Industry	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
						Millions of current dollars						
Total	3,165	3,393	3,094	3,269	3,633	3,650	4,624	5,226	6,295	6,814	7,727	8,690
Food, kindred, and tobacco products	54	62	64	63	70	75	69	37	27	41	40	63
Chemicals and allied products	603	715	682	729	786	843	1,071	1,243	1,501	1,504	1,990	2,323
Industrial and other chemicals	246	287	319	368	385	444	579	625	781	508	547	701
Drugs and medicines	357	428	363	361	401	399	492	618	720	996	1,443	1,622
Petroleum refining and extraction	141	194	133	103	101	47	40	47	58	45	71	97
Stone, clay, and glass products	21	18	10	19	60	NA	NA	NA	NA	NA	263	NA
Primary metals	11	9	9	10	9	NA	NA	18	24	26	30	24
Fabricated metal products	NA	30	25	23	21	21	26	40	NA	46	65	NA
Machinery	599	612	494	577	740	689	951	1,233	1,364	1,515	1,580	1,653
Electrical equipment	451	475	467	482	537	591	NA	432	669	574	671	620
Transportation equipment	1,020	884	843	880	907	1,025	NA	NA	1,801	NA	NA	NA
Professional and scientific instruments	186	230	237	NA	263	169	212	317	393	449	563	588
Nonmanufacturing industries	7	8	7	10	8	18	27	64	95	108	114	139
						Millions of constant 1987 dollars[1]						
Total	4,414	4,300	3,692	3,749	3,992	3,867	4,772	5,226	6,059	6,280	6,826	7,377
Food, kindred, and tobacco products	75	79	76	72	77	79	71	37	26	38	35	53
Chemicals and allied products	841	906	814	836	864	893	1,105	1,243	1,445	1,386	1,758	1,972
Industrial and other chemicals	343	364	381	422	423	470	598	625	752	468	483	595
Drugs and medicines	498	542	433	414	441	423	508	618	693	918	1,275	1,377
Petroleum refining and extraction	197	246	159	118	111	50	41	47	56	41	63	82
Stone, clay, and glass products	29	23	12	22	66	NA	NA	NA	NA	NA	232	NA
Primary metals	15	11	11	11	10	NA	NA	18	23	24	27	20
Fabricated metal products	NA	38	30	26	23	22	27	40	NA	42	57	
Machinery	835	776	589	662	813	730	981	1,233	1,313	1,396	1,396	1,403
Electrical equipment	629	602	557	553	590	626	NA	432	644	529	593	526
Transportation equipment	1,423	1,120	1,006	1,009	997	1,086	NA	NA	1,733	NA	NA	NA
Professional and scientific instruments	259	292	283	NA	289	179	219	317	378	414	497	499
Nonmanufacturing industries	10	10	8	11	9	19	28	64	91	100	101	118

(continued)

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Appendix table 4-40.

Company-financed R&D performed abroad by U.S. companies and their foreign subsidiaries, by industry: 1980–91

(page 2 of 2)

Industry	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	U.S. overseas R&D performance as a percentage of company-financed domestic R&D											
Total	10.4	9.6	7.7	7.3	7.1	6.4	7.7	8.5	9.6	9.7	10.4	11.3
Food, kindred, and tobacco products	NA	9.7	8.2	7.6	6.5	6.6	5.4	3.1	2.3	3.2	3.1	4.6
Chemicals and allied products	14.1	13.7	11.0	10.7	10.2	10.1	12.4	13.2	14.2	13.2	16.2	17.7
Industrial and other chemicals	9.8	9.1	8.6	9.4	8.7	9.2	11.6	11.7	13.4	8.2	7.9	10.0
Drugs and medicines	20.3	20.7	14.7	12.5	12.1	11.5	13.5	15.1	15.2	19.3	26.9	26.6
Petroleum refining and extraction	10.1	10.9	6.6	5.0	4.5	2.1	2.0	2.5	3.0	2.2	3.4	4.3
Stone, clay, and glass products	NA	4.4	2.1	3.2	8.5	NA	NA	NA	NA	NA	29.4	NA
Primary metals	1.9	1.3	1.3	1.4	1.3	NA	NA	2.5	3.7	3.6	3.7	2.9
Fabricated metal products	NA	5.5	4.4	3.6	2.7	2.7	3.2	6.3	NA	6.9	10.1	
Machinery	11.4	10.0	6.8	7.3	7.9	6.4	8.9	11.7	11.4	11.2	11.5	11.8
Electrical equipment	8.3	7.4	7.0	5.9	5.9	6.4	NA	4.1	6.0	4.9	5.5	5.0
Transportation equipment	14.7	11.4	9.8	9.8	8.7	8.5	NA	NA	12.7	NA	NA	NA
Professional and scientific instruments	7.6	7.7	7.0	NA	6.2	3.7	4.5	6.4	7.4	8.0	9.2	9.0
Nonmanufacturing industries	0.7	0.8	0.5	0.5	0.2	0.4	0.6	1.2	1.8	1.9	1.7	2.0

NA = not available

[1] See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCE: Science Resources Studies Division, National Science Foundation, *Research and Development in Industry: 1991* (Washington, DC: NSF, forthcoming).

See figure 4-28.

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Appendix table 4–41.

R&D expenditures performed for majority-owned foreign affiliates of U.S. parent companies, by country: 1982 and 1989–91

Country	1982	1989	1990	1991
	Millions of current U.S. dollars			
Total	3,647	7,048	10,187	9,358
Canada	545	914	1,159	1,037
Europe	2,591	5,178	7,952	7,109
Belgium	181	317	388	383
France	263	545	882	871
Germany	893	1,496	2,561	2,503
Ireland	31	134	539	573
Italy	136	294	476	327
The Netherlands	101	360	459	477
Spain	36	115	103	100
Sweden	29	33	130	83
Switzerland	51	67	76	91
United Kingdom	805	1,673	2,221	1,612
Other European countries	65	144	117	89
Asia and the Pacific	294	760	846	914
Australia	120	181	197	144
Japan	104	488	512	595
Singapore	D	25	54	87
Other Asian and Pacific countries	D	247	83	88
Latin America and other Western Hemisphere	179	153	201	253
Brazil	96	90	113	149
Mexico	38	37	53	64
Other Latin America countries	45	26	35	40
Middle East	11	32	16	30
Africa	26	11	13	15
South Africa	23	9	10	12
Other African countries	3	2	3	3

D = withheld to avoid disclosing operations of individual companies

NOTES: Data include foreign direct investments of nonbank U.S. affiliates only and R&D expenditures conducted by and for the foreign affiliates. The data exclude expenditures for R&D conducted for others under a contract. The expenditures reported here differ from those in appendix table 4–40.

SOURCE: Bureau of Economic Analysis, *U.S. Direct Investment Abroad* (Washington, DC: BEA, annual series).

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Appendix table 4–42.
Distribution of strategic technology alliances between economic blocs, by technology: 1980–84 and 1985–89

	U.S.–Europe		U.S.–Japan		U.S.–Japan	
Technology	1980–84	1985–89	1980–84	1985–89	1980–84	1985–89
Total	338	586	272	307	100	149
Biotechnology	58	124	45	54	5	20
New materials	32	52	16	40	15	23
Information	158	256	133	132	57	57
Automotive	10	24	10	39	6	16
Aviation/defense	24	31	7	3	1	0
Chemicals	31	54	35	28	14	21
Food and beverages	3	4	0	2	2	2
Heavy electrical equipment	13	22	9	4	0	4
Instruments/medical	9	19	17	5	0	6

SOURCE: John Hagedoorn and Jos Schakenraad, "Strategic Technology Partnering and International Corporate Strategies," in *European Competitiveness*, Kirsty Hughes, ed. (Cambridge, United Kingdom: Cambridge University Press, 1993).

See figure 4–27.

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Appendix table 4–43.
Percentage of industrial R&D performance financed from foreign sources, by selected country: 1981–91

	United States	Canada	France	Germany[1]	Italy	Japan	United Kingdom
	Percent						
1981	6.2	7.4	7.2	1.2	4.3	0.1	8.7
1982	6.5	10.7	4.8	1.3	4.7	0.1	NA
1983	6.5	16.7	4.6	1.4	4.3	0.1	6.8
1984	6.5	17.2	6.5	1.5	6.2	0.1	NA
1985	6.4	14.3	6.9	1.4	6.1	0.1	11.1
1986	6.8	13.7	8.0	1.4	7.3	0.1	12.2
1987	7.3	16.9	8.7	1.5	6.9	0.1	12.0
1988	8.2	18.1	9.2	2.1	6.6	0.1	12.0
1989	9.5	16.9	10.9	2.7	6.5	0.1	13.4
1990	11.1	17.7	11.1	3.0	7.3	0.1	15.5
1991	NA	17.7	NA	3.1	5.1	0.1	16.0

NA = not available

NOTE: For the United States, foreign expenditures are from companies with at least 10 percent foreign ownership.

[1] German data are for the former West Germany only.

SOURCE: Organisation for Economic Co-operation and Development, Main Science and Technology Indicators database; and Bureau of Economic Analysis, *Foreign Direct Investment in the United States* (Washington, DC: BEA, annual series).

See figure 4-29.

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Appendix table 4–44.

Foreign R&D expenditures in the United States, by industry and country: 1977–90

Industry and country	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Millions of current dollars													
Total	933	1,230	1,584	1,946	3,110	3,744	4,164	4,738	5,240	5,804	6,521	7,834	9,465	11,324
Expenditures by industry														
Manufacturing	851	1,099	1,450	D	2,898	3,388	3,863	4,424	4,866	5,391	5,884	7,267	8,785	10,257
Petroleum	108	158	149	D	253	255	310	366	388	380	311	364	387	520
Food and kindred products	7	16	14	19	32	39	44	43	51	54	58	106	187	204
Chemicals and allied products	483	604	773	834	1,580	1,870	2,037	2,349	2,627	2,782	3,220	3,719	4,371	5,183
Industrial chemicals	181	234	308	454	1,085	1,329	1,397	1,620	1,836	1,657	1,899	2,126	2,284	2,521
Other chemicals	127	176	201	146	179	170	181	200	228	167	230	276	252	287
Drugs and medicines	175	194	264	234	316	371	459	529	563	958	1,091	1,318	1,835	2,375
Primary metal industries	16	11	15	24	71	79	59	66	102	97	91	102	155	164
Fabricated metal products	21	16	30	21	20	28	82	54	64	76	67	106	209	163
Machinery, except electrical	69	94	129	189	284	297	350	355	342	286	476	692	1,070	1,138
Office and computing machines	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	370	497	622	748
Other	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	106	195	448	390
Electrical equipment	98	131	229	318	385	505	613	799	977	1,366	1,105	1,389	1,371	1,839
Transportation equipment	4	4	26	101	136	150	92	95	83	124	76	225	265	190
Professional and scientific instruments	15	18	28	32	52	47	42	42	58	112	279	242	366	371
Nonmanufacturing industries	82	131	134	D	212	356	301	314	374	413	637	567	680	1,067
Services	19	20	14	37	43	41	51	60	54	77	243	69	108	183
Other	63	111	120	D	169	315	250	254	320	336	394	498	572	884
Expenditures by country														
Canada	74	85	102	135	777	1,032	1,212	1,405	1,550	1,542	1,666	1,804	1,758	1,955
Europe	790	996	1,253	1,544	1,936	2,229	2,324	2,632	2,918	3,450	3,881	4,754	6,022	7,412
France	62	89	56	146	204	232	215	261	166	352	366	435	572	810
Germany[1]	101	189	311	380	436	529	591	602	671	851	1,139	1,242	1,503	1,754
The Netherlands	190	215	244	299	373	397	387	432	514	517	542	618	703	805
Sweden	10	12	14	36	53	54	62	63	116	141	128	166	214	259
Switzerland	241	287	352	338	416	447	463	546	625	744	765	962	1,195	1,657
United Kingdom	155	176	252	312	405	520	559	664	748	764	833	1,171	1,645	1,864
Other European countries	31	28	24	33	49	50	47	64	78	81	108	160	2,968	3,632
Japan	23	54	77	88	142	141	171	210	267	292	307	571	822	1,215
Latin America	35	73	132	D	D	D	401	423	427	427	391	352	400	381
Rest of world	11	22	20	D	D	D	56	68	78	93	276	353	463	361
	Millions of constant 1987 dollars[2]													
Total	1,669	2,040	2,415	2,714	3,942	4,468	4,775	5,207	5,551	5,990	6,521	7,540	8,724	10,004

D = withheld to avoid disclosing operations of individual companies; NA = not available

NOTES: Includes foreign direct investments of nonbank U.S. affiliates with 10 percent or more foreign ownership. Excludes expenditures for R&D conducted for others under a contract.

[1] German data are for the former West Germany only.

[2] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCE: Bureau of Economic Analysis, *Foreign Direct Investment in the United States* (Washington, DC: BEA, annual series).

Appendix table 4–45.
R&D expenditures in the United States by majority-owned U.S. affiliates of foreign companies, by industry of affiliate and country of ultimate beneficial owner: 1980 and 1987–90

Industry and country	1980	1987	1988	1989	1990
	Millions of current dollars				
Total	1,517	4,497	5,485	6,720	8,403
Expenditures by industry					
Manufacturing	1,420	4,092	5,112	6,293	7,703
Food and kindred products	19	58	105	185	201
Chemicals and allied products	733	D	D	D	D
Industrial and other chemicals	501	D	D	D	D
Drugs and medicines	232	1,075	1,293	1,806	2,365
Petroleum	175	283	339	378	491
Rubber products	8	50	98	117	153
Stone, clay, and glass products	10	32	61	62	113
Primary metal industries	D	38	37	75	70
Fabricated metal products	D	62	100	201	150
Machinery, except electrical	92	D	446	556	639
Computer and office equipment	28	D	285	295	371
Other	65	79	161	260	267
Electrical and electronic equipment	285	D	1,114	1,078	1,558
Household audio & video, and communications equipment	66	555	777	721	999
Electronic components and other	219	D	337	357	559
Transportation equipment	10	D	D	D	100
Professional and scientific instruments	28	254	210	295	283
Nonmanufacturing industries	97	405	373	427	700
Services	5	59	42	77	75
Wholesale trade	69	312	300	297	567
Motor vehicles and equipment	D	86	67	71	283
Electrical goods	5	71	107	D	106
Other	23	34	31	53	58
Expenditures by country					
Canada	113	D	D	D	D
Europe	1,217	3,458	4,241	5,414	6,669
France	39	332	402	510	767
Germany[1]	281	824	963	1,216	1,422
Italy	D	D	73	93	92
The Netherlands	D	540	615	690	779
Sweden	D	124	160	205	249
Switzerland	329	D	D	1,060	1,455
United Kingdom	247	790	1,085	1,568	1,786
Other European countries	16	47	D	72	119
Asia and the Pacific	D	179	345	412	777
Australia	2	5	4	9	14
Japan	D	133	282	369	695
Other Asian and Pacific countries	D	41	59	34	68
Latin America and other western hemisphere	155	329	302	352	315
Middle East	2	14	9	10	10
Africa	D	D	D	D	D
South Africa	D	D	D	D	4
Other African countries	D	D	0	0	D
	Millions of constant 1987 dollars[2]				
Total	2,116	4,497	5,279	6,194	7,423

D = withheld to avoid disclosing operations of individual companies; NA = not available

NOTES: Includes foreign direct investments of nonbank U.S. affiliates with 50 percent or more foreign ownership. These R&D expenditures are a subset of total foreign R&D expenditures, reported in appendix table 4–44. Excludes expenditures for R&D conducted for others under a contract.

[1] German data are for the former West Germany only.

[2] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCE: Bureau of Economic Analysis, special tabulations.

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Appendix table 4–46.

Government funding of academic and academically related research, by field and country: 1987

Field	United States	Japan	West Germany	France	United Kingdom	Canada	The Netherlands	Australia	Unweighted average
	Millions of constant U.S. 1987 dollars[1]								
Total	14,904	3,736	4,037	3,212	2,787	1,267	958	738	—
	Percent								
Engineering	13.2	21.6	12.5	11.2	15.6	11.9	11.7	7.9	13.2
Physical sciences	15.6	14.5	25.1	29.7	20.3	13.7	21.7	13.7	19.3
Environmental sciences	5.8	3.7	4.5	5.3	6.3	3.7	2.8	9.4	5.2
Math & computer sciences	4.0	2.3	3.9	5.4	7.5	5.2	3.5	4.2	4.5
Life sciences	48.9	33.7	36.7	34.7	31.0	38.2	32.7	36.0	36.5
Social sciences and psych.	5.1	3.9	5.2	4.6	6.7	10.3	10.4	12.2	7.3
Professional & vocational	3.3	9.9	5.0	2.1	5.8	8.7	8.5	6.4	6.2
Arts and humanities	2.8	9.6	6.2	6.8	6.6	7.5	8.6	10.1	7.3
Multidisciplinary[2]	1.5	0.8	0.8	0.1	0.3	0.9	0.1	0.0	0.6

[1] Conversions of foreign currencies to U.S. dollars were calculated with the Organisation for Economic Co-operation and Development purchasing power parity exchange rates available in early 1989.

[2] Research not elsewhere classified.

SOURCE: B.R. Martin and J. Irvine, "Trends in Government Spending on Academic and Related Research: An International Comparison," *Science and Public Policy*, Vol. 19, No. 5:315.

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Appendix table 5–1.
Expenditures for academic basic research, applied research, and development: 1960–93

	Total academic R&D	Basic research	Applied research	Develop-ment	Total academic R&D	Basic research	Applied research	Develop-ment	Basic research	Applied research	Develop-ment
	Millions of current dollars				Millions of constant 1987 dollars[1]				Percentage of total		
1960	646	433	179	34	2,475	1,659	686	130	67.0	27.7	5.3
1961	763	536	192	35	2,901	2,038	730	133	70.2	25.2	4.6
1962	904	659	205	40	3,373	2,459	765	149	72.9	22.7	4.4
1963	1,081	814	227	40	3,974	2,993	835	147	75.3	21.0	3.7
1964	1,275	1,003	232	40	4,620	3,634	841	145	78.7	18.2	3.1
1965	1,474	1,138	279	57	5,208	4,021	986	201	77.2	18.9	3.9
1966	1,715	1,303	328	84	5,893	4,478	1,127	289	76.0	19.1	4.9
1967	1,921	1,457	374	90	6,382	4,841	1,243	299	75.8	19.5	4.7
1968	2,149	1,650	403	96	6,888	5,288	1,292	308	76.8	18.8	4.5
1969	2,225	1,711	407	107	6,784	5,216	1,241	326	76.9	18.3	4.8
1970	2,335	1,796	427	112	6,749	5,191	1,234	324	76.9	18.3	4.8
1971	2,500	1,914	474	112	6,887	5,273	1,306	309	76.6	19.0	4.5
1972	2,630	2,022	524	84	6,885	5,293	1,372	220	76.9	19.9	3.2
1973	2,884	2,053	713	118	7,174	5,107	1,774	294	71.2	24.7	4.1
1974	3,022	2,153	736	133	6,979	4,972	1,700	307	71.2	24.4	4.4
1975	3,409	2,410	851	148	7,162	5,063	1,788	311	70.7	25.0	4.3
1976	3,729	2,549	1,016	164	7,283	4,979	1,984	320	68.4	27.2	4.4
1977	4,067	2,800	1,067	200	7,341	5,054	1,926	361	68.8	26.2	4.9
1978	4,625	3,133	1,184	308	7,760	5,257	1,987	517	67.7	25.6	6.7
1979	5,380	3,628	1,313	439	8,315	5,607	2,029	679	67.4	24.4	8.2
1980	6,077	4,042	1,536	499	8,608	5,725	2,176	707	66.5	25.3	8.2
1981	6,847	4,593	1,731	523	8,801	5,904	2,225	672	67.1	25.3	7.6
1982	7,323	4,878	1,858	587	8,760	5,835	2,222	702	66.6	25.4	8.0
1983	7,881	5,303	1,988	590	9,059	6,095	2,285	678	67.3	25.2	7.5
1984	8,620	5,732	2,254	634	9,483	6,306	2,480	697	66.5	26.1	7.4
1985	9,686	6,553	2,420	713	10,271	6,949	2,566	756	67.7	25.0	7.4
1986	10,928	7,490	2,629	809	11,254	7,714	2,708	833	68.5	24.1	7.4
1987	12,154	8,392	2,912	850	12,154	8,392	2,912	850	69.0	24.0	7.0
1988	13,466	8,893	3,519	1,054	12,998	8,584	3,397	1,017	66.0	26.1	7.8
1989	15,016	9,801	4,080	1,135	13,878	9,058	3,771	1,049	65.3	27.2	7.6
1990	16,344	10,681	4,363	1,300	14,502	9,477	3,871	1,154	65.4	26.7	8.0
1991	17,620	11,538	4,570	1,512	15,086	9,878	3,913	1,295	65.5	25.9	8.6
1992 (est.)	19,050	12,400	4,920	1,730	15,862	10,325	4,097	1,440	65.1	25.8	9.1
1993 (est.)	20,550	13,500	5,360	1,690	16,707	10,976	4,358	1,374	65.7	26.1	8.2

[1] See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *National Patterns of R&D Resources: 1992*, NSF 92-330 (Washington, DC: NSF, 1992); and SRS, unpublished tabulations.

See figure 5-2.

Appendix table 5–2.

Support for academic R&D, by sector: FYs 1960–93

(page 1 of 2)

	Total	Federal Government	State/local government	Industry	Academic institutions	All other sources
			Millions of current dollars			
1960	646	405	85	40	64	52
1961	763	500	95	40	70	58
1962	904	613	106	40	79	66
1963	1,081	760	118	41	89	73
1964	1,275	917	132	40	103	83
1965	1,474	1,073	143	41	124	93
1966	1,715	1,261	156	42	148	108
1967	1,921	1,409	164	48	181	119
1968	2,149	1,572	172	55	218	132
1969	2,225	1,600	197	60	223	145
1970	2,335	1,647	219	61	243	165
1971	2,500	1,724	255	70	274	177
1972	2,630	1,795	269	74	305	187
1973	2,884	1,985	295	84	318	202
1974	3,022	2,032	308	95	368	219
1975	3,409	2,288	332	113	417	259
1976	3,729	2,512	363	123	446	285
1977	4,067	2,726	374	139	514	314
1978[1]	4,625	3,059	414	170	623	359
1979	5,380	3,604	476	194	738	368
1980	6,077	4,104	497	236	837	403
1981	6,847	4,571	545	292	1,004	435
1982	7,323	4,768	616	337	1,111	491
1983	7,881	4,989	625	389	1,302	576
1984	8,620	5,430	690	475	1,411	614
1985	9,686	6,063	752	560	1,617	694
1986	10,928	6,710	916	700	1,868	734
1987	12,154	7,341	1,024	790	2,168	831
1988	13,466	8,191	1,107	872	2,355	941
1989	15,016	8,991	1,235	998	2,712	1,080
1990	16,344	9,636	1,339	1,134	3,017	1,218
1991	17,620	10,221	1,481	1,216	3,369	1,333
1992 (est.)[1]	19,050	10,800	1,650	1,350	3,750	1,500
1993 (est.)[1]	20,550	11,400	1,850	1,500	4,150	1,650
			Millions of constant 1987 dollars[2]			
1960	2,475	1,552	326	153	245	199
1961	2,901	1,901	361	152	266	221
1962	3,373	2,287	396	149	295	246
1963	3,974	2,794	434	151	327	268
1964	4,620	3,322	478	145	373	301
1965	5,208	3,792	505	145	438	329
1966	5,893	4,333	536	144	509	371
1967	6,382	4,681	545	159	601	395
1968	6,888	5,038	551	176	699	423
1969	6,784	4,878	601	183	680	442
1970	6,749	4,760	633	176	702	477
1971	6,887	4,749	702	193	755	488
1972	6,885	4,699	705	194	798	490
1973	7,174	4,938	733	209	792	502
1974	6,979	4,693	711	219	850	506
1975	7,162	4,807	697	237	877	544
1976	7,283	4,906	710	240	870	557
1977	7,341	4,921	675	251	928	567
1978[1]	7,760	5,133	695	285	1,045	602
1979	8,315	5,570	736	300	1,140	569

(continued)

Appendix table 5–2.
Support for academic R&D, by sector: FYs 1960–93
(page 2 of 2)

	Total	Federal Government	State/local government	Industry	Academic institutions	All other sources
			Millions of constant 1987 dollars[2]			
1980	8,608	5,813	704	334	1,186	571
1981	8,801	5,875	701	375	1,290	559
1982	8,760	5,703	737	403	1,329	587
1983	9,059	5,734	718	447	1,497	662
1984	9,483	5,974	759	523	1,552	675
1985	10,271	6,429	797	594	1,715	736
1986	11,254	6,910	943	721	1,924	756
1987	12,154	7,341	1,024	790	2,168	831
1988	12,998	7,906	1,069	842	2,273	908
1989	13,878	8,310	1,141	922	2,506	998
1990	14,502	8,550	1,188	1,006	2,677	1,081
1991	15,086	8,751	1,268	1,041	2,884	1,141
1992 (est.)[1]	15,862	8,993	1,374	1,124	3,122	1,249
1993 (est.)[1]	16,707	9,268	1,504	1,220	3,374	1,341
			Percent			
1960	100.0	62.7	13.2	6.2	9.9	8.0
1961	100.0	65.5	12.5	5.2	9.2	7.6
1962	100.0	67.8	11.7	4.4	8.7	7.3
1963	100.0	70.3	10.9	3.8	8.2	6.8
1964	100.0	71.9	10.4	3.1	8.1	6.5
1965	100.0	72.8	9.7	2.8	8.4	6.3
1966	100.0	73.5	9.1	2.4	8.6	6.3
1967	100.0	73.3	8.5	2.5	9.4	6.2
1968	100.0	73.2	8.0	2.6	10.1	6.1
1969	100.0	71.9	8.9	2.7	10.0	6.5
1970	100.0	70.5	9.4	2.6	10.4	7.1
1971	100.0	69.0	10.2	2.8	11.0	7.1
1972	100.0	68.3	10.2	2.8	11.6	7.1
1973	100.0	68.8	10.2	2.9	11.0	7.0
1974	100.0	67.2	10.2	3.1	12.2	7.2
1975	100.0	67.1	9.7	3.3	12.2	7.6
1976	100.0	67.4	9.7	3.3	11.9	7.6
1977	100.0	67.0	9.2	3.4	12.6	7.7
1978[1]	100.0	66.1	9.0	3.7	13.5	7.8
1979	100.0	67.0	8.8	3.6	13.7	6.8
1980	100.0	67.5	8.2	3.9	13.8	6.6
1981	100.0	66.8	8.0	4.3	14.7	6.4
1982	100.0	65.1	8.4	4.6	15.2	6.7
1983	100.0	63.3	7.9	4.9	16.5	7.3
1984	100.0	63.0	8.0	5.5	16.4	7.1
1985	100.0	62.6	7.8	5.8	16.7	7.2
1986	100.0	61.4	8.4	6.4	17.1	6.7
1987	100.0	60.4	8.4	6.5	17.8	6.8
1988	100.0	60.8	8.2	6.5	17.5	7.0
1989	100.0	59.9	8.2	6.6	18.1	7.2
1990	100.0	59.0	8.2	6.9	18.5	7.5
1991	100.0	58.0	8.4	6.9	19.1	7.6
1992 (est.)[1]	100.0	56.7	8.7	7.1	19.7	7.9
1993 (est.)[1]	100.0	55.5	9.0	7.3	20.2	8.0

[1] Relative amounts of funds from state and local governments and from academic institutions are estimated from previous year's ratio.

[2] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Academic Science and Engineering: R&D Expenditures: Fiscal Year 1991*, Detailed Statistical Tables, NSF 93-308 (Washington, DC: NSF, 1993); and SRS, annual series.

See figure 5–3.

Appendix table 5–3.
Sources of R&D funds at private and public institutions, by sector: 1981 and 1991

Year and institution type	Total	Federal Government	State/local government	Industry	Academic institutions	Other sources
	Millions of dollars					
1981						
Private	2,458	1,941	47	111	183	176
Public	4,389	2,630	499	180	821	259
1991						
Private	5,845	4,177	144	417	576	531
Public	11,776	6,044	1,339	799	2,792	802
	Percent					
1981						
Private	100.0	79.0	1.9	4.5	7.4	7.1
Public	100.0	59.9	11.4	4.1	18.7	5.9
1991						
Private	100.0	71.5	2.5	7.1	9.9	9.1
Public	100.0	51.3	11.4	6.8	23.7	6.8

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Academic Science and Engineering: R&D Expenditures: Fiscal Year 1991, Detailed Statistical Tables*, NSF 93-308 (Washington, DC: NSF, 1993); and SRS, annual series.

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Appendix table 5–4.
R&D expenditures at the top 100 academic institutions, by source of funds: 1991
(page 1 of 2)

Rank and academic institution	Institution type	Total	Federal Government	State/local government	Industry	Academic institutions	All other sources
		Millions of dollars					
Total, all institutions[1]		17,181	9,791	1,483	1,216	3,359	1,333
1 University of Michigan-all campuses	Public	364	206	3	31	94	29
2 University of Minnesota-all campuses	Public	331	165	54	19	61	33
3 University of Wisconsin-Madison	Public	326	184	57	13	47	26
4 Massachusetts Institute of Technology	Private	319	238	3	46	9	23
5 Stanford University	Private	310	242	1	12	37	18
6 Cornell University-all campuses	Private	310	173	41	17	55	23
7 Texas A & M University-all campuses	Public	288	98	78	23	78	11
8 University of Washington	Public	274	221	6	26	18	4
9 Johns Hopkins University[1]	Private	271	212	1	15	19	24
10 University of California-San Francisco	Public	269	191	13	5	33	26
Total, 1st 10 institutions		3,062	1,930	257	207	451	218
11 Pennsylvania State Univ.-all campuses	Public	268	146	9	38	75	*
12 University of California-San Diego	Public	261	200	8	11	23	18
13 University of California-Berkeley	Public	258	140	24	12	66	16
14 University of California-Los Angeles	Public	250	168	5	9	36	32
15 Univ. of Illinois at Urbana-Champaign	Public	243	119	34	24	58	8
16 University of Texas-Austin	Public	237	113	9	6	75	34
17 Harvard University	Private	230	156	*	12	19	43
18 University of Arizona	Public	214	102	6	12	79	15
19 University of Maryland-College Park	Public	206	78	60	12	56	0
20 University of California-Davis	Public	201	80	12	7	88	13
Total, 1st 20 institutions		5,431	3,232	424	349	1,028	398
21 University of Pennsylvania	Private	198	144	4	7	16	27
22 Ohio State University-all campuses	Public	195	89	33	15	27	32
23 Columbia University-main campus	Private	195	164	3	7	5	16
24 Yale University	Private	194	150	1	9	15	20
25 Georgia Inst. of Technology-all campuses	Public	177	101	2	22	51	0
26 University of Southern California	Private	176	132	6	14	23	0
27 Duke University	Private	164	115	2	23	13	12
28 University of Georgia	Public	163	45	38	6	73	1
29 University of Colorado-all campuses	Public	162	119	2	8	16	16
30 Baylor College of Medicine	Private	161	79	4	7	21	50
Total, 1st 30 institutions		7,215	4,370	518	467	1,288	572
31 Washington University	Private	160	112	4	16	13	15
32 Louisiana State University-all campuses	Public	151	57	56	8	23	7
33 Rutgers State Univ. of NJ-all campuses	Public	151	49	25	8	61	9
34 Northwestern University	Private	145	63	3	7	56	17
35 University of North Carolina-Chapel Hill	Public	143	103	18	4	17	0
36 North Carolina State University-Raleigh	Public	143	47	50	21	20	5
37 University of Florida	Public	140	67	12	13	42	6
38 Purdue University-all campuses	Public	136	68	18	12	32	7
39 Iowa State University	Public	135	43	31	7	49	5
40 Michigan State University	Public	133	62	25	5	32	10
Total, 1st 40 institutions		8,653	5,040	761	568	1,632	652
41 University of Rochester	Private	132	107	7	7	1	10
42 University of Pittsburgh-all campuses	Public	130	100	1	7	9	13
43 University of Tennessee Central Office	Public	128	64	25	9	24	7
44 Virginia Polytechnic Inst. & State Univ.	Public	125	48	39	12	22	4
45 University of Iowa	Public	124	81	3	8	25	7
46 University of Massachusetts-all campuses	Public	120	68	7	10	29	6
47 University of Connecticut-all campuses	Public	120	46	5	7	53	8
48 University of Chicago	Private	117	94	2	1	10	10
49 California Institute of Technology	Private	116	101	*	3	7	5
50 SUNY at Buffalo-all campuses	Public	113	69	4	3	21	16
Total, 1st 50 institutions		9,878	5,817	854	636	1,834	737

(continued)

Appendix table 5–4.
R&D expenditures at the top 100 academic institutions, by source of funds: 1991
(page 2 of 2)

Rank and academic institution	Institution type	Total	Federal Government	State/local government	Industry	Academic institutions	All other sources
				Millions of dollars			
51 University of Alabama-Birmingham	Public	113	76	3	8	11	15
52 New York University	Private	112	82	1	6	9	14
53 Univ. of Texas MD Anderson Cancer Center	Public	109	32	0	0	56	21
54 Case Western Reserve University	Private	104	76	3	5	9	11
55 Carnegie Mellon University	Private	103	65	6	20	2	9
56 Indiana University-all campuses	Public	102	62	1	2	27	10
57 University of Miami	Private	97	70	2	7	4	14
58 University of Missouri-Columbia	Public	97	27	13	10	42	5
59 University of Virginia-all campuses	Public	97	61	7	8	10	11
60 Oregon State University	Public	96	51	24	4	8	9
Total, 1st 60 institutions		10,909	6,420	914	705	2,013	857
61 University of Utah	Public	95	69	3	3	16	4
62 U. of Texas Southwestern Med Ctr Dallas	Public	95	58	*	9	6	21
63 Utah State University	Public	94	62	13	2	15	2
64 Princeton University	Private	92	52	2	5	25	9
65 Emory University	Private	92	61	3	7	14	7
66 SUNY at Stony Brook-all campuses	Public	91	59	2	3	21	6
67 University of Illinois-Chicago	Public	91	43	4	5	29	10
68 U. of Maryland Baltimore Prof. Schools	Public	90	44	16	12	11	7
69 University of Nebraska-Lincoln	Public	88	27	33	3	22	2
70 Yeshiva University	Private	87	68	0	2	11	6
Total, 1st 70 institutions		11,822	6,963	990	755	2,182	932
71 University of California-Irvine	Public	83	53	3	4	13	9
72 University of Kentucky-all campuses	Public	81	32	6	7	31	5
73 Vanderbilt University	Private	81	71	*	2	3	5
74 University of Cincinnati-all campuses	Public	81	47	3	4	18	8
75 Colorado State University	Public	80	56	10	3	8	4
76 University of Oklahoma-all campuses	Public	80	26	8	4	30	12
77 New Mexico State University-all campuses	Public	79	58	9	5	7	1
78 University of Hawaii-Manoa	Public	78	45	27	1	3	2
79 Woods Hole Oceanographic Institution	Private	77	67	1	1	2	6
80 Washington State University	Public	75	32	5	2	28	8
Total, 1st 80 institutions	12,616	7,449	1,062	789	2,325	992	
81 Boston University	Private	75	60	*	6	0	8
82 Rockefeller University	Private	74	37	*	5	16	16
83 U. of Medicine & Dentistry of New Jersey	Public	73	39	8	3	16	6
84 University of South Florida	Public	73	24	5	6	32	6
85 Tulane University of Louisiana	Private	72	37	2	7	20	7
86 Clemson University	Public	70	17	15	6	29	3
87 Wayne State University	Public	70	31	6	7	21	6
88 Auburn University-all campuses	Public	70	15	22	6	21	5
89 Oklahoma State University-all campuses	Public	67	16	5	2	43	1
90 Univ. of Alaska Fairbanks-all campuses	Public	67	34	2	2	28	1
Total, 1st 90 institutions		13,328	7,757	1,127	840	2,552	1,051
91 University of New Mexico-all campuses	Public	67	30	5	5	17	11
92 Mount Sinai School of Medicine	Private	66	42	1	4	7	12
93 University of Kansas-all campuses	Public	66	26	2	4	31	2
94 Virginia Commonwealth University	Public	66	45	2	6	10	2
95 Mississippi State University	Public	64	26	21	7	7	4
96 Arizona State University	Public	63	26	1	7	28	1
97 Georgetown University	Private	60	42	*	5	9	5
98 University of California-Santa Barbara	Public	60	47	1	2	6	4
99 University of California-Riverside	Public	57	16	3	1	34	3
100 Univ. of South Carolina-all campuses	Public	55	23	2	8	21	2
Total, 1st 100 institutions		13,954	8,080	1,165	889	2,722	1,097

* = less than $1 million

[1] These figures exclude the Applied Physics Laboratory (APL) at Johns Hopkins University, which is similar to a federally funded research and development center and dominates the R&D performed at the university. In 1991 APL had total R&D expenditures of $439 million, of which $430 million was provided by federal sources.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Academic Science and Engineering: R&D Expenditures: Fiscal Year 1991*, Detailed Statistical Tables, NSF 93-308 (Washington, DC: NSF, 1993); and SRS, unpublished tabulations.

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Appendix table 5–5.

Industrial support for R&D at the top 200 R&D-performing academic institutions: FY 1991

(page 1 of 3)

Rank and academic institution	Industrial support: Thousands of dollars	Industrial support: Percentage of total R&D
Rank 1–25 ($177–$364 million): average industrial share		6.3
Massachusetts Institute of Technology	45,712	14.3
Pennsylvania State University-all campuses	37,587	14.0
Georgia Institute of Technology-all campuses	22,496	12.7
University of Illinois at Urbana-Champaign	24,434	10.0
University of Washington	26,033	9.5
University of Michigan-all campuses	30,807	8.5
Texas A & M University-all campuses	23,050	8.0
Ohio State University-all campuses	15,409	7.9
University of Minnesota-all campuses	19,270	5.8
University of Maryland-College Park	11,938	5.8
University of Arizona	12,091	5.7
Johns Hopkins University	14,953	5.5
Cornell University-all campuses	16,761	5.4
Harvard University	11,957	5.2
University of California-Berkeley	11,970	4.6
Yale University	8,700	4.5
University of California-San Diego	11,225	4.3
University of Wisconsin-Madison	12,624	3.9
Stanford University	11,935	3.8
University of Pennsylvania	7,171	3.6
University of California-Los Angeles	8,619	3.4
Columbia University-main campus	6,619	3.4
University of California-Davis	6,599	3.3
University of Texas-Austin	5,734	2.4
University of California-San Francisco	5,475	2.0
Rank 26–50 ($113–$176 million): average industrial share		6.4
North Carolina State University-Raleigh	20,961	14.7
Duke University	22,876	13.9
Washington University	16,442	10.2
Virginia Polytechnic Institute and State University	12,443	9.9
University of Florida	13,376	9.5
Purdue University-all campuses	11,962	8.8
University of Massachusetts-all campuses	10,271	8.6
University of Southern California	13,852	7.9
University of Tennessee Central Office	8,857	6.9
University of Iowa	7,828	6.3
University of Connecticut-all campuses	7,421	6.2
Louisiana State University-all campuses	8,477	5.6
University of Pittsburgh-all campuses	7,110	5.5
University of Rochester	6,814	5.2
Rutgers State University of New Jersey-all campuses	7,769	5.1
University of Colorado-all campuses	8,251	5.1
Iowa State University	6,537	4.9
Northwestern University	6,960	4.8
Baylor College of Medicine	7,294	4.5
University of Georgia	5,821	3.6
Michigan State University	4,693	3.5
SUNY at Buffalo-all campuses	3,086	2.7
University of North Carolina-Chapel Hill	3,677	2.6
California Institute of Technology	2,764	2.4
University of Chicago	1,425	1.2
Rank 51–75 ($80–$113 million): average industrial share		6.2
Carnegie Mellon University	20,438	19.8
University of Maryland Baltimore Professional Schools	11,898	13.2
University of Texas Southwestern Medical Center Dallas	9,330	9.9
University of Missouri-Columbia	9,537	9.9
University of Kentucky-all campuses	7,476	9.2
University of Virginia-all campuses	8,153	8.4
Emory University	6,920	7.5
University of Alabama-Birmingham	7,867	6.9
University of Miami	6,593	6.8
University of Illinois-Chicago	4,844	5.4
New York University	5,947	5.3
University of California-Irvine	4,163	5.0
University of Cincinnati-all campuses	4,050	5.0
Princeton University	4,595	5.0
Case Western Reserve University	4,667	4.5
Colorado State University	3,380	4.2
Oregon State University	3,776	3.9
University of Nebraska-Lincoln	2,806	3.2
University of Utah	2,908	3.1
SUNY at Stony Brook-all campuses	2,783	3.1
Vanderbilt University	1,941	2.4
Indiana University-all campuses	2,367	2.3
Utah State University	2,155	2.3
Yeshiva University	1,601	1.8
University of Texas MD Anderson Cancer Center[1]	0	0.0

(continued)

Appendix table 5–5.

Industrial support for R&D at the top 200 R&D-performing academic institutions: FY 1991

(page 2 of 3)

Rank and academic institution	Industrial support: Thousands of dollars	Industrial support: Percentage of total R&D
Rank 76–100 ($55–$80 million): average industrial share		6.6
University of South Carolina-all campuses	7,625	13.8
Mississippi State University	7,163	11.1
Arizona State University	6,860	10.8
Wayne State University	7,295	10.4
Virginia Commonwealth University	6,201	9.5
Tulane University of Louisiana	6,758	9.4
Auburn University-all campuses	6,450	9.2
Clemson University	6,163	8.8
Boston University	6,405	8.6
University of South Florida	6,091	8.3
Georgetown University	4,549	7.5
University of New Mexico-all campuses	4,684	7.0
Rockefeller University	4,816	6.5
University of Kansas-all campuses	4,228	6.4
New Mexico State University-all campuses	4,939	6.3
Mount Sinai School of Medicine	3,978	6.0
University of Medicine and Dentistry of New Jersey	3,471	4.7
University of Oklahoma-all campuses	3,530	4.4
University of California-Santa Barbara	2,379	4.0
Oklahoma State University-all campuses	2,473	3.7
Washington State University	2,074	2.8
University of California-Riverside	1,361	2.4
University of Alaska Fairbanks-all campuses	1,547	2.3
University of Hawaii-Manoa	856	1.1
Woods Hole Oceanographic Institution[2]	786	1.0
Rank 101–125 ($35–$55 million): average industrial share		9.4
Rensselaer Polytechnic Institute	12,236	24.4
West Virginia University	11,163	22.5
Tufts University[2]	7,740	16.2
Texas Tech University	4,763	13.6
Wake Forest University	5,927	13.4
University of Texas Health Science San Antonio	6,876	13.3
University of Texas Health Science Center-Houston	6,392	11.9
University of Dayton	4,359	11.5
University of Idaho	4,447	11.3
University of Delaware	4,732	10.6
Medical College of Wisconsin	4,175	10.3
University of Central Florida	4,287	10.2
University of Vermont	4,181	9.0
University of Arkansas-main campus	3,323	8.1
Temple University	3,452	6.3
University of Texas Medical Branch-Galveston	2,652	5.9
Dartmouth College	2,719	5.5
Brown University	2,497	5.0
Kansas State Univ. of Agriculture & Applied Science	2,389	4.5
University of Houston-University Park	1,608	3.8
University of Rhode Island	1,212	3.1
Oregon Health Science University	1,099	2.6
Florida State University	1,408	2.6
SUNY Health Science Center-Syracuse	350	0.9
Uniformed Services University of the Health Sciences (Bethesda, MD)[1]	0	0.0
Rank 126–150 ($21–$34 million): average industrial share		10.0
Thomas Jefferson University	9,966	30.1
Lehigh University	8,133	29.1
University of Notre Dame	4,952	23.2
University of Maine at Orono	4,719	17.4
Rush University	4,092	15.0
Syracuse University-all campuses	4,405	14.4
Montana State University	4,043	13.4
Rice University	3,600	11.8
Medical College of Pennsylvania	2,496	10.1
University of Wyoming	2,000	8.7
Medical University of South Carolina	2,115	8.2
Southern Illinois University-Carbondale	2,190	7.7
San Diego State University	1,980	6.9
Loyola University of Chicago	1,545	6.8
University of Alabama-Huntsville	1,847	6.7
University of Nebraska Medical Center	1,682	6.0
University of Mississippi-all campuses	1,366	5.5
University of Nevada-Reno	1,276	4.4
University of New Hampshire-main campus	1,278	4.3
George Washington University	1,248	4.2
SUNY Health Science Center-Brooklyn	732	2.2
University of California-Santa Cruz	560	1.8
University of Puerto Rico Mayaguez[3]	312	1.0
University of Oregon	224	0.9
Brandeis University[1]	0	0.0

(continued)

Appendix table 5–5.

Industrial support for R&D at the top 200 R&D-performing academic institutions: FY 1991

(page 3 of 3)

Rank and academic institution	Industrial support Thousands of dollars	Industrial support Percentage of total R&D
Rank 151–175 ($14–$21 million): average industrial share		10.0
New Mexico Institute of Mining and Technology[3]	6,512	38.8
Michigan Technological University	4,150	21.1
Desert Research Institute	3,670	20.4
University of Louisville	3,093	18.4
Northeastern University[3]	2,491	15.6
Drexel University	2,873	14.6
New York Medical College	1,981	13.5
New Jersey Institute Technology	2,018	12.3
University of Alabama	2,396	11.3
University of Missouri-Rolla	1,564	10.8
North Dakota State University-all campuses	1,455	10.5
SUNY College of Environmental Science and Forestry	1,707	9.0
University of Arkansas for Medical Sciences	1,191	8.4
CUNY City College	1,032	6.7
Saint Louis University-all campuses	1,058	5.5
University of North Dakota-all campuses	853	5.0
SUNY at Albany	876	4.3
Wright State University-all campuses	562	3.8
University of Wisconsin-Milwaukee	499	3.0
College of William and Mary-all campuses	526	2.8
Howard University	312	2.0
University of Nevada-Las Vegas	377	1.9
Florida Agricultural and Mechanical University	142	0.8
Ctr for Environmental & Estuarine Studies, U. of MD	83	0.5
Naval Postgraduate School[1]	0	0.0
Rank 176–200 ($10–$14 million): average industrial share		13.5
Colorado School of Mines	4,847	37.4
University of North Texas	3,576	33.8
University of Lowell	3,599	29.0
University of Akron-all campuses	3,813	28.4
University of Texas-Dallas	2,403	22.7
University of Texas-Arlington	2,884	22.4
SUNY-Binghamton	1,761	17.8
Northern Illinois University	1,629	16.2
Oregon Graduate Institute of Science & Technology	1,673	15.0
Brigham Young University-all campuses	1,817	14.3
Medical College of Georgia	1,731	14.3
University of South Alabama	1,788	13.8
Old Dominion University	979	9.8
Tennessee Technological University	871	8.8
Cleveland State University	753	7.4
Albany Medical Center Graduate School	677	6.7
Ohio University-all campuses	839	6.6
Memphis State University	616	5.1
San Jose State University	588	4.9
North Carolina Agricultural & Technical State Univ.	366	3.5
South Dakota State University	250	2.2
Hahnemann University[3]	238	1.8
Boston College	134	1.4
University of Southwestern Louisiana[1]	0	0.0
Eastern Virginia Medical School[1]	0	0.0

NOTES: Rankings were derived by sorting academic institutions receiving R&D funding into groups of 25 from highest to lowest funding. Dollar ranges cited for each rank reflect the range of total R&D expenditures for the 25 institutions. Average industrial shares reflect data only from those campuses that reported receiving separate industrial R&D support.

[1] No industrial support was reported or industrial support data were not available.

[2] Data for industrial R&D support were estimated.

[3] Data for industrial support were imputed.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Academic Science and Engineering: R&D Expenditures: Fiscal Year 1991*, Detailed Statistical Tables, NSF 93-308 (Washington, DC: NSF, 1993); and SRS, unpublished tabulations.

See text table 5–1.

Science & Engineering Indicators – 1993

Appendix table 5–6.

Federal and nonfederal R&D expenditures at academic institutions, by field and source of funds: 1991

Field	Total		Federal	Nonfederal[1]	Federal	Nonfederal[1]
	Thousands of dollars	Percent	Thousands of dollars		Percent	
Total science and engineering	17,620,209	100.0	10,220,506	7,399,703	58.0	42.0
Total sciences	14,727,459	83.6	8,589,561	6,137,898	58.3	41.7
Physical sciences	1,936,857	11.0	1,378,592	558,265	71.2	28.8
Astronomy	210,148	1.2	135,362	74,786	64.4	35.6
Chemistry	669,998	3.8	449,644	220,354	67.1	32.9
Physics	883,038	5.0	677,582	205,456	76.7	23.3
Other	173,673	1.0	116,004	57,669	66.8	33.2
Mathematical sciences	229,495	1.3	169,147	60,348	73.7	26.3
Computer sciences	544,464	3.1	366,009	178,455	67.2	32.8
Environmental sciences	1,119,905	6.4	704,409	415,496	62.9	37.1
Atmospheric sciences	176,447	1.0	132,217	44,230	74.9	25.1
Earth sciences	380,034	2.2	215,982	164,052	56.8	43.2
Oceanography	396,403	2.2	267,903	128,500	67.6	32.4
Other	167,021	0.9	88,307	78,714	52.9	47.1
Life sciences	9,492,902	53.9	5,402,408	4,090,494	56.9	43.1
Agricultural sciences	1,463,848	8.3	379,108	1,084,740	25.9	74.1
Biological sciences	3,056,719	17.3	1,950,905	1,105,814	63.8	36.2
Medical sciences	4,569,054	25.9	2,830,739	1,738,315	62.0	38.0
Other	403,281	2.3	241,656	161,625	59.9	40.1
Psychology	293,440	1.7	194,267	99,173	66.2	33.8
Social sciences	745,988	4.2	247,188	498,800	33.1	66.9
Economics	210,296	1.2	58,800	151,496	28.0	72.0
Political science	121,465	0.7	28,800	92,665	23.7	76.3
Sociology	157,806	0.9	71,615	86,191	45.4	54.6
Other	256,421	1.5	87,973	168,448	34.3	65.7
Other sciences	364,408	2.1	127,541	236,867	35.0	65.0
Engineering	2,892,750	16.4	1,630,945	1,261,805	56.4	43.6
Aeronautical/astronautical	174,321	1.0	131,708	42,613	75.6	24.4
Chemical	238,553	1.4	114,310	124,243	47.9	52.1
Civil	315,134	1.8	122,874	192,260	39.0	61.0
Electrical/electronic	682,213	3.9	437,494	244,719	64.1	35.9
Mechanical	415,071	2.4	243,182	171,889	58.6	41.4
Other	1,067,458	6.1	581,377	486,081	54.5	45.5

[1] See appendix table 5-2 for detail on nonfederal sources.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Academic Science and Engineering: R&D Expenditures: Fiscal Year 1991*, Detailed Statistical Tables, NSF 93-308 (Washington, DC: NSF, 1993); and SRS, unpublished tabulations.

Science & Engineering Indicators – 1993

Appendix table 5–7.
Expenditures for academic R&D, by field: 1981–91
(page 1 of 2)

Field	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Millions of current dollars										
Total S&E	6,847	7,323	7,881	8,620	9,686	10,928	12,154	13,466	15,016	16,344	17,620
Total sciences	5,880	6,295	6,759	7,388	8,268	9,287	10,261	11,369	12,617	13,682	14,727
Physical sciences	766	824	901	1,001	1,149	1,287	1,391	1,546	1,638	1,796	1,937
Astronomy	67	73	73	80	96	102	108	127	137	170	210
Chemistry	285	308	335	372	421	470	514	565	608	650	670
Physics	358	367	418	474	551	631	667	732	775	832	883
Other	56	75	74	74	80	85	103	122	119	145	174
Mathematical sciences	87	96	106	123	128	152	177	199	214	220	229
Computer sciences	144	164	186	224	281	321	372	409	472	509	544
Environmental sciences	550	558	617	645	705	775	835	889	1,009	1,073	1,120
Atmospheric sciences	87	86	98	102	108	120	128	134	167	173	176
Earth sciences	190	195	216	228	254	274	284	294	323	354	380
Oceanography	192	198	224	237	258	280	300	333	365	383	396
Other	81	78	79	79	85	101	122	128	155	162	167
Life sciences	3,695	4,013	4,303	4,711	5,278	5,890	6,527	7,256	8,079	8,762	9,493
Agricultural sciences	790	864	921	954	999	1,089	1,121	1,176	1,286	1,356	1,464
Biological sciences	1,189	1,286	1,419	1,573	1,780	1,945	2,142	2,397	2,638	2,855	3,057
Medical sciences	1,605	1,739	1,830	2,034	2,318	2,616	3,000	3,378	3,828	4,182	4,569
Other	111	123	132	150	181	240	264	304	327	370	403
Psychology	127	131	136	145	158	170	188	213	237	258	293
Social sciences	367	354	345	359	383	463	503	553	637	702	746
Economics	99	95	98	109	118	136	150	163	188	202	210
Political science	55	60	55	56	59	69	81	87	104	112	121
Sociology	95	80	78	71	76	97	97	110	122	134	158
Other	117	118	114	123	130	161	175	192	223	254	256
Other sciences	145	156	165	180	186	228	269	304	331	360	364
Engineering	967	1,028	1,122	1,232	1,418	1,641	1,892	2,097	2,399	2,663	2,893
Aeronautical/astronautical	54	62	68	70	81	94	108	123	145	159	174
Chemical	86	89	96	102	116	132	148	163	194	215	239
Civil	109	116	127	140	153	178	191	225	247	285	315
Electrical/electronic	193	218	262	295	337	395	451	510	600	668	682
Mechanical	141	143	149	179	208	228	275	304	344	393	415
Other	384	399	420	447	523	613	719	773	869	943	1,067

(continued)

Appendix table 5–7.
Expenditures for academic R&D, by field: 1981–91
(page 2 of 2)

Field	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Millions of constant 1987 dollars[1]										
Total S&E	8,800	8,760	9,059	9,483	10,272	11,254	12,154	12,998	13,878	14,502	15,086
Total sciences	7,557	7,530	7,769	8,127	8,768	9,564	10,261	10,974	11,661	12,140	12,609
Physical sciences	985	986	1,035	1,101	1,218	1,326	1,391	1,492	1,514	1,594	1,658
Astronomy	86	87	84	89	102	105	108	122	126	150	180
Chemistry	366	369	385	409	447	484	514	546	562	577	574
Physics	460	439	480	521	585	650	667	706	716	738	756
Other	72	90	85	82	85	87	103	118	110	129	149
Mathematical sciences	112	115	122	135	136	156	177	192	197	196	196
Computer sciences	185	196	214	247	298	331	372	394	436	452	466
Environmental sciences	707	668	709	710	747	798	835	858	933	952	959
Atmospheric sciences	112	103	113	112	114	124	128	129	154	154	151
Earth sciences	244	233	248	250	269	283	284	284	298	314	325
Oceanography	247	237	257	260	274	288	300	322	338	340	339
Other	104	94	90	87	91	104	122	123	143	144	143
Life sciences	4,749	4,800	4,946	5,183	5,597	6,066	6,527	7,004	7,467	7,775	8,127
Agricultural sciences	1,015	1,034	1,059	1,050	1,060	1,122	1,121	1,135	1,189	1,204	1,253
Biological sciences	1,528	1,539	1,631	1,730	1,887	2,003	2,142	2,314	2,438	2,533	2,617
Medical sciences	2,063	2,080	2,104	2,237	2,459	2,694	3,000	3,260	3,538	3,710	3,912
Other	142	147	152	166	192	247	264	294	303	328	345
Psychology	163	156	156	160	168	175	188	206	219	229	251
Social sciences	471	423	397	395	407	477	503	533	589	623	639
Economics	127	114	113	119	125	140	150	158	174	179	180
Political science	71	72	63	62	63	71	81	84	96	99	104
Sociology	122	96	90	78	80	100	97	106	113	119	135
Other	150	141	131	136	138	166	175	186	206	225	220
Other sciences	186	186	189	197	198	235	269	294	306	320	312
Engineering	1,243	1,230	1,290	1,355	1,504	1,690	1,892	2,024	2,217	2,363	2,477
Aeronautical/astronautical	70	75	79	77	85	97	108	119	134	141	149
Chemical	110	107	110	112	123	136	148	157	179	191	204
Civil	140	139	145	154	162	183	191	217	228	253	270
Electrical/electronic	248	261	301	325	358	407	451	492	555	592	584
Mechanical	181	171	172	197	220	235	275	293	318	348	355
Other	494	478	483	492	554	632	719	746	803	837	914

S&E = science and engineering.

[1] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Academic Science and Engineering: R&D Expenditures: Fiscal Year 1991*, Detailed Statistical Tables, NSF 93-308 (Washington, DC: NSF, 1993); and SRS, unpublished tabulations.

See figure 5–4.

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Appendix table 5-8.

Federal financing of academic R&D funds, by field: 1973–91

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Percentage federally financed																		
Total S&E	68.8	67.2	67.1	67.4	67.0	66.2	67.0	67.5	66.8	65.1	63.3	63.0	62.6	61.4	60.4	60.8	59.9	59.0	58.0
Total sciences	68.5	67.0	67.0	67.4	67.0	65.9	66.7	67.4	66.5	64.8	62.9	62.8	62.8	61.7	60.7	61.2	60.3	59.3	58.3
Physical sciences	81.8	81.0	81.4	80.5	80.0	79.6	81.5	81.9	80.8	78.8	77.7	78.1	77.5	76.3	75.2	74.5	72.6	72.5	71.2
Astronomy	73.4	70.0	73.4	69.8	71.8	71.6	74.8	75.6	71.0	70.6	68.0	66.1	67.0	68.5	65.7	66.1	64.0	66.1	64.4
Chemistry	76.1	76.6	76.8	77.0	76.2	75.8	75.8	77.7	76.0	74.7	73.8	75.0	74.2	72.0	71.7	71.3	69.3	68.3	67.1
Physics	87.1	86.6	86.4	85.3	85.2	84.9	86.4	86.8	86.4	83.5	82.1	82.3	82.2	80.9	79.6	78.5	77.2	77.3	76.7
Other	79.7	74.4	77.7	77.2	73.7	72.6	82.7	78.7	81.1	81.2	80.4	80.1	75.0	75.8	75.1	74.7	69.4	71.6	66.8
Mathematical sciences	77.5	78.4	78.6	77.4	77.7	75.7	77.6	78.4	77.8	74.5	71.9	75.0	75.9	75.4	74.4	75.3	73.0	72.0	73.7
Computer sciences	69.9	73.2	74.3	74.0	67.6	62.2	70.9	70.4	72.4	74.2	74.6	72.7	69.7	72.4	69.1	70.8	68.3	66.8	67.2
Environmental sciences	75.2	71.7	70.8	73.4	74.7	72.7	72.6	73.1	71.1	70.1	69.1	69.1	67.2	66.6	65.0	65.9	65.1	63.9	62.9
Atmospheric sciences	NA	NA	NA	NA	NA	NA	NA	84.1	76.9	79.9	78.4	80.7	79.9	81.3	82.5	81.7	78.8	76.1	74.9
Earth sciences	NA	NA	NA	NA	NA	NA	NA	69.7	67.1	64.9	62.4	61.4	60.7	58.3	56.2	59.3	57.7	57.5	56.8
Oceanography	NA	NA	NA	NA	NA	NA	NA	77.6	77.9	77.4	76.6	76.4	72.7	74.3	72.6	71.6	72.8	69.8	67.6
Other	75.2	71.7	70.8	73.4	74.7	72.7	72.6	59.1	58.0	53.5	54.2	54.0	53.8	50.2	48.9	49.9	47.9	51.0	52.9
Life sciences	66.3	64.5	65.1	65.7	65.3	63.9	64.0	64.8	64.0	62.4	60.2	60.1	60.4	59.3	58.8	59.6	59.2	57.9	56.9
Agricultural sciences	34.1	29.2	29.4	29.7	28.8	29.2	30.5	31.1	29.7	29.5	28.4	28.2	29.4	26.8	26.6	27.4	27.1	26.0	25.9
Biological sciences	71.6	71.7	72.5	73.5	74.5	72.8	72.6	74.0	73.0	71.4	69.4	69.5	67.9	67.4	66.2	66.8	65.7	64.5	63.8
Medical sciences	75.3	75.9	75.6	75.5	74.9	73.1	73.7	74.4	74.1	72.0	68.9	67.6	68.0	66.6	65.4	65.5	65.3	63.7	62.0
Other	70.3	72.5	71.8	72.6	71.7	70.6	70.1	67.3	67.5	64.0	61.0	62.9	60.0	61.3	59.8	61.5	60.5	58.9	59.9
Psychology	79.5	78.9	76.8	76.2	74.8	71.4	72.3	73.3	72.7	68.2	66.1	67.4	67.0	66.9	66.0	65.8	65.7	65.2	66.2
Social sciences	57.3	56.9	55.2	52.7	51.6	51.1	53.0	53.8	51.0	45.6	42.6	39.8	40.1	37.3	33.5	34.1	33.2	32.0	33.1
Economics	47.6	46.6	48.2	44.5	43.8	48.1	48.4	48.9	45.4	43.7	39.6	39.1	37.0	33.5	29.0	30.1	28.8	26.8	28.0
Political science	40.6	44.0	41.8	42.2	46.2	42.1	46.0	43.4	42.0	37.3	36.8	33.9	33.1	29.3	29.6	28.9	24.6	22.3	23.7
Sociology	65.8	65.1	65.5	62.1	61.1	61.0	63.6	65.0	60.6	58.6	55.4	54.2	53.6	51.4	46.3	44.2	44.0	44.4	45.4
Other	61.0	60.0	55.9	54.8	52.9	50.6	51.9	54.1	52.2	42.7	39.1	35.0	38.3	35.6	32.0	34.2	34.9	33.9	34.3
Other sciences	58.7	57.1	57.2	59.5	54.9	57.4	54.9	53.6	56.5	56.5	52.7	48.5	49.3	47.1	45.8	43.1	41.4	43.0	35.0
Engineering	71.5	69.0	68.1	67.3	67.6	67.9	68.7	68.6	68.5	67.2	65.5	64.0	61.2	59.6	58.8	58.6	57.7	57.2	56.4
Aeronautical/astronautical	NA	NA	NA	NA	NA	NA	NA	79.5	80.0	79.1	78.7	78.2	76.4	77.0	74.1	76.3	77.0	77.2	75.6
Chemical	NA	NA	NA	NA	NA	NA	NA	64.4	66.9	62.0	59.5	59.1	55.6	55.4	51.7	52.6	52.1	50.1	47.9
Civil	NA	NA	NA	NA	NA	NA	NA	64.0	56.8	51.5	50.4	51.8	51.5	49.6	47.0	45.8	41.3	40.7	39.0
Electrical/electronic	NA	NA	NA	NA	NA	NA	NA	75.7	75.9	77.1	73.8	71.0	67.7	65.9	64.8	64.8	64.9	65.2	64.1
Mechanical	NA	NA	NA	NA	NA	NA	NA	67.0	67.5	68.3	67.1	66.5	64.6	64.9	64.9	63.4	62.1	60.8	58.6
Other	71.5	69.0	68.1	67.3	67.6	67.9	68.7	65.7	67.3	65.3	63.5	61.1	57.3	54.6	55.0	54.9	53.5	53.4	54.5

NA = not available; S&E = science and engineering

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Academic Science and Engineering: R&D Expenditures: Fiscal Year 1991*, Detailed Statistical Tables, NSF 93-308 (Washington, DC: NSF, 1993); and SRS, annual series.

Science & Engineering Indicators – 1993

Appendix table 5–9.
Federal obligations for academic R&D, by agency: 1971–93
(page 1 of 2)

	All agencies	National Institutes of Health	National Science Foundation	Department of Defense	National Aeronautics & Space Admin.	Department of Energy[1]	Department of Agriculture	All other agencies
	Millions of current dollars							
1971	1,645	603	267	211	134	94	72	264
1972	1,904	756	362	217	119	85	87	277
1973	1,917	761	374	204	111	83	94	289
1974	2,214	1,027	389	197	99	94	95	312
1975	2,411	1,077	435	203	108	132	108	348
1976	2,552	1,185	437	240	119	145	120	307
1977	2,905	1,311	511	273	118	188	140	364
1978	3,375	1,493	537	383	127	240	186	408
1979	3,889	1,765	617	438	139	260	200	470
1980	4,263	1,888	685	495	158	285	216	536
1981	4,466	1,984	702	573	171	300	243	492
1982	4,605	2,026	715	664	186	277	255	483
1983	4,966	2,264	783	724	189	297	275	434
1984	5,547	2,560	880	830	204	321	261	491
1985	6,340	2,974	1,002	940	237	357	293	536
1986	6,559	3,044	992	1,098	254	345	274	553
1987	7,337	3,638	1,096	1,017	294	386	280	626
1988	7,828	3,886	1,143	1,071	338	406	305	678
1989	8,672	4,157	1,254	1,189	434	454	328	858
1990	9,142	4,305	1,321	1,213	471	500	348	984
1991	10,169	4,662	1,436	1,152	534	621	386	1,379
1992 (est.)	11,298	4,922	1,574	1,599	632	640	424	1,507
1993 (est.)	11,764	5,181	1,838	1,558	675	576	416	1,519
	Millions of constant 1987 dollars[2]							
1971	4,531	1,662	734	581	369	259	198	727
1972	4,983	1,979	949	567	312	221	229	726
1973	4,768	1,893	932	507	277	206	234	719
1974	5,113	2,372	899	456	228	217	219	722
1975	5,066	2,262	914	427	227	277	227	732
1976	4,984	2,314	853	470	232	283	234	599
1977	5,245	2,367	922	493	212	340	253	657
1978	5,662	2,505	901	643	213	403	313	684
1979	6,011	2,728	953	677	214	402	309	727
1980	6,039	2,674	970	702	223	404	307	759
1981	5,740	2,551	902	736	220	386	312	632
1982	5,509	2,423	855	794	222	331	305	578
1983	5,709	2,602	900	832	218	341	316	499
1984	6,102	2,816	968	913	224	353	287	540
1985	6,723	3,154	1,062	997	252	379	311	568
1986	6,755	3,135	1,021	1,131	262	355	282	570
1987	7,337	3,638	1,096	1,017	294	386	280	626
1988	7,556	3,751	1,104	1,034	326	392	294	655
1989	8,015	3,842	1,159	1,099	401	419	303	793
1990	8,112	3,820	1,172	1,076	418	444	309	873
1991	8,706	3,992	1,229	986	457	531	330	1,180
1992 (est.)	9,407	4,098	1,311	1,331	526	533	353	1,255
1993 (est.)	9,564	4,212	1,494	1,267	549	468	338	1,235

(continued)

Appendix table 5-9.
Federal obligations for academic R&D, by agency: 1971–93
(page 2 of 2)

	All agencies	National Institutes of Health	National Science Foundation	Department of Defense	National Aeronautics & Space Admin.	Department of Energy[1]	Department of Agriculture	All other agencies
	Percent							
1971	100.0	36.7	16.2	12.8	8.2	5.7	4.4	16.0
1972	100.0	39.7	19.0	11.4	6.3	4.4	4.6	14.6
1973	100.0	39.7	19.5	10.6	5.8	4.3	4.9	15.1
1974	100.0	46.4	17.6	8.9	4.5	4.2	4.3	14.1
1975	100.0	44.6	18.0	8.4	4.5	5.5	4.5	14.4
1976	100.0	46.4	17.1	9.4	4.7	5.7	4.7	12.0
1977	100.0	45.1	17.6	9.4	4.0	6.5	4.8	12.5
1978	100.0	44.2	15.9	11.4	3.8	7.1	5.5	12.1
1979	100.0	45.4	15.9	11.3	3.6	6.7	5.1	12.1
1980	100.0	44.3	16.1	11.6	3.7	6.7	5.1	12.6
1981	100.0	44.4	15.7	12.8	3.8	6.7	5.4	11.0
1982	100.0	44.0	15.5	14.4	4.0	6.0	5.5	10.5
1983	100.0	45.6	15.8	14.6	3.8	6.0	5.5	8.7
1984	100.0	46.2	15.9	15.0	3.7	5.8	4.7	8.8
1985	100.0	46.9	15.8	14.8	3.7	5.6	4.6	8.5
1986	100.0	46.4	15.1	16.7	3.9	5.3	4.2	8.4.0
1987	100.0	49.6	14.9	13.9	4.0	5.3	3.8	8.5
1988	100.0	49.6	14.6	13.7	4.3	5.2	3.9	8.7
1989	100.0	47.9	14.5	13.7	5.0	5.2	3.8	9.9
1990	100.0	47.1	14.4	13.3	5.2	5.5	3.8	10.8
1991	100.0	45.9	14.1	11.3	5.2	6.1	3.8	13.6
1992 (est.)	100.0	43.6	13.9	14.1	5.6	5.7	3.8	13.3
1993 (est.)	100.0	44.0	15.6	13.2	5.7	4.9	3.5	12.9

NOTE: Percentages may not total 100 because of rounding.

[1] Data for 1971–73 are for the Atomic Energy Commission; for 1974–76, the Energy Research and Development Administration; and for 1977–93, the Department of Energy.

[2] See appendix table 4-1 for GDP implicit price deflators used to convert current dollars to constant 1987 dollars.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Federal Funds for Research and Development: Fiscal Years 1991, 1992, and 1993* (Washington, DC: NSF, 1993); and SRS, annual series.

Science & Engineering Indicators – 1993

Appendix table 5–10.
Number of academic institutions receiving federal R&D support, by field: 1971, 1981, and 1991

	All Carnegie institutions[1]			Research & doctoral institutions			All other Carnegie institutions		
Field	1971	1981	1991	1971	1981	1991	1971	1981	1991
Total science & engineering . .	565	618	759	207	203	204	358	415	555
Physical sciences	279	322	414	178	181	189	101	141	225
Mathematical sciences	159	180	282	140	144	164	19	36	118
Computer sciences[2]	NA	117	240	NA	102	181	NA	15	59
Environmental sciences.	192	246	319	137	152	174	55	94	145
Life sciences	378	454	514	191	192	195	187	262	319
Psychology.	304	222	231	171	148	153	133	74	78
Social sciences.	330	322	301	172	166	161	158	156	140
Engineering	232	256	313	154	169	180	78	87	133

NA = not available

NOTES: Since 1989, the Department of Defense (DOD) no longer provides detailed R&D funding information by science field. Therefore, 1991 data cited here do not reflect those institutions that received federal R&D funding in a particular field only from DOD. Details do not add to totals because institutions may receive grants in more than one field.

[1] See chapter 2, "Classification of Academic Institutions," for information on the institutional categories used by the Carnegie Foundation for the Advancement of Teaching.

[2] Data on computer sciences were not separately reported in 1971.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Federal Support to Universities, Colleges, and Nonprofit Institutions: Fiscal Year 1990*, Detailed Statistical Tables, NSF 92-324 (Washington, DC: NSF, 1992); and SRS, unpublished tabulations.

See figure 5–5.

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Appendix table 5–11.
Cost of new academic R&D construction, by field: 1986–93

	Total cost[1]				Cost per square foot			
Field	1986–87 actual	1988–89 actual	1990–91 actual	1992–93 planned	1986–87 actual	1988–89 actual	1990–91 actual	1992–93 planned
	Millions of dollars				Dollars			
Total, all fields	2,051	2,464	2,976	3,214	207	231	260	259
Physical sciences.	182	401	430	282	228	201	267	392
Mathematical sciences	2	8	12	4	222	320	261	154
Computer sciences.	61	65	40	120	257	227	137	268
Environmental sciences	57	82	170	110	150	253	321	139
Agricultural sciences.	150	152	175	199	99	133	183	169
Biological sciences	463	577	832	780	271	255	297	277
Medical sciences	505	647	807	996	259	287	273	260
Psychology	23	25	36	50	174	217	220	327
Social sciences	38	48		115	188	146		276
Other sciences.	139	70	79	87	231	167	208	279
Engineering	430	388	395	471	180	260	233	273

NOTES: Data for 2 years are combined—e.g., 1988–89 refers to 2 fiscal years. In the 1990–91 period, data were not differentiated between psychology and the social sciences.

[1] Project cost estimates are prorated to reflect R&D component only.

SOURCE: Science Resources Studies Division, National Science Foundation, *Scientific and Engineering Research Facilities at Universities and Colleges: 1992*, NSF 92-325 (Washington, DC: NSF, 1993).

Science & Engineering Indicators – 1993

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Appendix table 5–12.

Square footage of total, new construction, and renovation of academic R&D space, by field: 1986–93

Field	Total R&D space				New R&D space				Renovated R&D space			
	1986 actual	1988 actual	1990 actual	1992 actual	1986–87 actual	1988–89 actual	1990–91 actual	1992–93 planned	1986–87 actual	1988–89 actual	1990–91 actual	1992–93 planned
	Thousands of square feet											
Total, all fields	NA	112,062	116,327	122,015	9,922	10,647	11,433	12,405	13,431	11,449	8,606	5,986
Physical sciences	NA	16,024	16,121	16,353	799	2,000	1,609	719	1,746	1,630	1,159	1,037
Mathematical sciences	NA	722	790	829	9	25	46	26	37	136	39	17
Computer sciences	NA	1,437	1,445	1,606	237	286	293	447	193	144	164	34
Environmental sciences	NA	6,313	6,056	6,728	380	324	529	792	362	930	450	360
Agricultural sciences	NA	17,622	20,821	19,910	1,513	1,146	955	1,176	628	530	391	302
Biological sciences	NA	23,910	26,154	27,721	1,708	2,262	2,800	2,813	3,611	3,451	2,356	1,513
Medical sciences	NA	19,363	19,721	22,374	1,948	2,253	2,961	3,826	3,236	2,302	2,070	1,547
Psychology	NA	3,085	2,978	2,984	132	115	164	153	256	88	254	129
Social sciences	NA	3,337	3,338	3,253	202	329		417	181	119		141
Other sciences	NA	4,350	1,846	2,162	603	418	380	312	465	180	42	1,544
Engineering	NA	15,900	17,057	18,095	2,390	1,490	1,697	1,725	2,716	1,630	1,159	1,037

NOTES: Data for 2 years are combined—e.g., 1988–89 refers to 2 fiscal years. In the 1986–87 period, data were not reported for total R&D space. In the 1990–91 period, data for new and renovated R&D space were not differentiated between psychology and the social sciences.

SOURCE: Science Resources Studies Division, National Science Foundation, *Scientific and Engineering Research Facilities at Universities and Colleges: 1992*, NSF 92-325 (Washington, DC: NSF, 1992).

Science & Engineering Indicators – 1993

Appendix table 5–13.

Current fund expenditures for research equipment at academic institutions, by field: 1981–91

(page 1 of 2)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Thousands of current dollars										
Total expenditures											
Total, all fields	412,478	426,234	450,735	536,552	671,321	782,614	836,662	912,090	989,770	1,020,434	1,026,339
Physical sciences	77,185	80,601	80,749	103,498	141,829	162,895	165,972	180,928	179,773	190,291	189,483
Mathematical sciences	2,630	3,664	3,740	5,328	6,013	6,814	9,774	9,695	10,504	9,980	11,048
Computer sciences	14,986	17,518	19,945	22,251	35,451	42,579	42,779	42,762	42,894	47,891	58,082
Environmental sciences	30,426	28,169	31,063	41,227	47,779	51,270	55,257	55,598	67,593	72,861	69,838
Life sciences	195,598	203,166	209,254	242,893	282,481	330,531	335,224	379,542	432,884	424,167	411,070
Psychology	5,718	5,788	6,560	7,285	8,669	8,616	10,518	9,567	10,530	10,697	11,245
Social sciences	7,766	7,891	9,447	13,798	10,032	14,049	11,755	11,847	14,704	15,123	14,230
Other sciences	7,285	8,982	10,430	10,318	14,714	20,060	27,093	26,680	26,628	26,581	27,676
Engineering	70,884	70,455	79,547	89,954	124,353	145,800	178,290	195,471	204,260	222,843	233,667
Federal expenditures											
Total, all fields	261,628	274,339	280,635	341,762	432,253	501,231	526,269	576,609	595,655	604,514	607,429
Physical sciences	59,386	63,927	63,673	82,658	113,252	130,509	130,392	142,346	132,370	143,042	138,385
Mathematical sciences	1,853	2,608	2,482	4,086	4,935	5,183	7,587	7,549	6,919	6,496	6,569
Computer sciences	9,624	13,235	14,498	16,851	29,407	35,121	33,921	34,733	30,755	31,936	43,446
Environmental sciences	18,241	17,913	19,171	29,317	32,339	34,997	35,848	36,506	44,890	47,962	43,657
Life sciences	117,667	118,590	114,958	137,199	157,019	188,405	187,797	215,097	238,233	222,103	217,556
Psychology	4,140	4,099	4,568	4,970	6,190	5,819	8,051	6,530	6,855	6,674	7,121
Social sciences	3,370	2,988	3,103	3,887	4,028	4,267	3,418	3,271	4,771	4,755	5,009
Other sciences	4,061	5,724	6,241	5,598	6,793	11,722	13,929	12,744	13,339	12,219	11,194
Engineering	43,286	45,255	51,941	57,196	78,290	85,208	105,326	117,833	117,523	129,327	134,492
Nonfederal expenditures											
Total, all fields	150,850	151,895	170,100	194,790	239,068	281,383	310,393	335,481	394,115	415,920	418,910
Physical sciences	17,799	16,674	17,076	20,840	28,577	32,386	35,580	38,582	47,403	47,249	51,098
Mathematical sciences	777	1,056	1,258	1,242	1,078	1,631	2,187	2,146	3,585	3,484	4,479
Computer sciences	5,362	4,283	5,447	5,400	6,044	7,458	8,858	8,029	12,139	15,955	14,636
Environmental sciences	12,185	10,256	11,892	11,910	15,440	16,273	19,409	19,092	22,703	24,899	26,181
Life sciences	77,931	84,576	94,296	105,694	125,462	142,126	147,427	164,445	194,651	202,064	193,514
Psychology	1,578	1,689	1,992	2,315	2,479	2,797	2,467	3,037	3,675	4,023	4,124
Social sciences	4,396	4,903	6,344	9,911	6,004	9,782	8,337	8,576	9,933	10,368	9,221
Other sciences	3,224	3,258	4,189	4,720	7,921	8,338	13,164	13,936	13,289	14,362	16,482
Engineering	27,598	25,200	27,606	32,758	46,063	60,592	72,964	77,638	86,737	93,516	99,175

(continued)

Appendix table 5–13.

Current fund expenditures for research equipment at academic institutions, by field: 1981–91

(page 2 of 2)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Thousands of constant 1987 dollars[1]										
Total expenditures											
Total, all fields	530,177	509,849	518,086	590,266	711,899	805,988	836,662	880,396	914,760	905,443	878,715
Physical sciences	99,210	96,413	92,815	113,859	150,402	167,760	165,972	174,641	166,149	168,847	162,229
Mathematical sciences	3,380	4,383	4,299	5,861	6,376	7,018	9,774	9,358	9,708	8,855	9,459
Computer sciences	19,262	20,955	22,925	24,479	37,594	43,851	42,779	41,276	39,643	42,494	49,728
Environmental sciences	39,108	33,695	35,705	45,354	50,667	52,801	55,257	53,666	62,470	64,650	59,793
Life sciences	251,411	243,022	240,522	267,209	299,556	340,403	335,224	366,353	400,078	376,368	351,943
Psychology	7,350	6,923	7,540	8,014	9,193	8,873	10,518	9,235	9,732	9,492	9,628
Social sciences	9,982	9,439	10,859	15,179	10,638	14,469	11,755	11,435	13,590	13,419	12,183
Other sciences	9,364	10,744	11,989	11,351	15,603	20,659	27,093	25,753	24,610	23,586	23,695
Engineering	91,111	84,276	91,433	98,959	131,870	150,154	178,290	188,679	188,780	197,731	200,057
Federal expenditures											
Total, all fields	336,283	328,157	322,569	375,976	458,381	516,201	526,269	556,572	550,513	536,392	520,059
Physical sciences	76,332	76,468	73,187	90,933	120,098	134,407	130,392	137,400	122,338	126,923	118,480
Mathematical sciences	2,382	3,120	2,853	4,495	5,233	5,338	7,587	7,287	6,395	5,764	5,624
Computer sciences	12,370	15,831	16,664	18,538	31,185	36,170	33,921	33,526	28,424	28,337	37,197
Environmental sciences	23,446	21,427	22,036	32,252	34,294	36,042	35,848	35,237	41,488	42,557	37,378
Life sciences	151,243	141,854	132,136	150,934	166,510	194,032	187,797	207,623	220,178	197,075	186,264
Psychology	5,321	4,903	5,251	5,468	6,564	5,993	8,051	6,303	6,335	5,922	6,097
Social sciences	4,332	3,574	3,567	4,276	4,271	4,394	3,418	3,157	4,409	4,219	4,289
Other sciences	5,220	6,847	7,174	6,158	7,204	12,072	13,929	12,301	12,328	10,842	9,584
Engineering	55,638	54,133	59,702	62,922	83,022	87,753	105,326	113,738	108,616	114,753	115,147
Nonfederal expenditures											
Total, all fields	193,895	181,693	195,517	214,290	253,519	289,787	310,393	323,823	364,247	369,051	358,656
Physical sciences	22,878	19,945	19,628	22,926	30,304	33,353	35,580	37,241	43,811	41,925	43,748
Mathematical sciences	999	1,263	1,446	1,366	1,143	1,680	2,187	2,071	3,313	3,091	3,835
Computer sciences	6,892	5,123	6,261	5,941	6,409	7,681	8,858	7,750	11,219	14,157	12,531
Environmental sciences	15,662	12,268	13,669	13,102	16,373	16,759	19,409	18,429	20,982	22,093	22,415
Life sciences	100,168	101,167	108,386	116,275	133,046	146,371	147,427	158,731	179,899	179,294	165,680
Psychology	2,028	2,020	2,290	2,547	2,629	2,881	2,467	2,931	3,396	3,570	3,531
Social sciences	5,650	5,865	7,292	10,903	6,367	10,074	8,337	8,278	9,180	9,200	7,895
Other sciences	4,144	3,897	4,815	5,193	8,400	8,587	13,164	13,452	12,282	12,744	14,111
Engineering	35,473	30,144	31,731	36,037	48,847	62,402	72,964	74,940	80,164	82,978	84,910

[1] See appendix table 4–1 for GDP implicit price deflators used to convert current dollars into constant 1987 dollars.

SOURCES: Science Resources Studies Division (SRS), National Science Foundation, *Academic Science and Engineering: R&D Expenditures: Fiscal Year 1991*, Detailed Statistical Tables, NSF 93-308 (Washington, DC: NSF, 1993); and SRS, annual series.

See figure 5–7.

Appendix table 5–14.

Doctoral scientists and engineers employed by academic institutions and those active in R&D, by field and sex: 1979, 1981, 1989, and 1991

	Total employment				Total with responsibility for R&D							
	1979	1981	1989	1991	1979	1981	1989	1991	1979	1981	1989	1991
	Number				Number				Percent			
Total												
Total science & engineering	135,841	147,787	177,974	177,805	88,686	94,888	135,739	134,647	65.3	64.2	76.3	75.7
Total sciences	122,938	133,582	159,819	158,480	79,050	86,098	121,098	118,827	64.3	64.5	75.8	75.0
Physical sciences	20,094	20,935	22,223	21,826	13,395	13,887	17,107	16,320	66.7	66.3	77.0	74.8
Mathematics	10,313	10,466	11,170	12,342	5,945	5,979	7,916	8,750	57.6	57.1	70.9	70.9
Computer sciences	1,980	2,506	4,810	6,084	1,305	1,581	3,256	4,230	65.9	63.1	67.7	69.5
Environmental sciences	4,786	5,483	6,406	6,632	3,668	4,136	5,716	5,841	76.6	75.4	89.2	88.1
Life sciences	44,616	49,003	62,329	61,827	33,243	36,720	51,069	50,449	74.5	74.9	81.9	81.6
Psychology	15,227	16,932	19,866	17,887	7,608	8,582	11,547	10,667	50.0	50.7	58.1	59.6
Social sciences	25,922	28,257	33,015	31,882	13,886	15,213	24,487	22,570	53.6	53.8	74.2	70.8
Engineering	12,903	14,205	18,155	19,325	9,636	8,790	14,641	15,820	74.7	61.9	80.6	81.9
Men												
Total science & engineering	119,192	128,249	145,355	142,206	78,925	82,907	112,114	109,440	66.2	64.6	77.1	77.0
Total sciences	106,383	114,170	127,699	123,546	69,363	74,215	97,916	94,239	65.2	65.0	76.7	76.3
Physical sciences	18,782	19,416	20,186	19,758	12,669	12,985	15,663	15,021	67.5	66.9	77.6	76.0
Mathematics	9,580	9,652	10,078	11,116	5,594	5,587	7,291	7,925	58.4	57.9	72.3	71.3
Computer sciences	1,875	2,342	4,366	5,394	1,238	1,486	2,923	3,763	66.0	63.5	66.9	69.8
Environmental sciences	4,537	5,167	5,760	5,906	3,493	3,894	5,136	5,188	77.0	75.4	89.2	87.8
Life sciences	37,661	40,964	47,703	45,409	28,335	30,805	39,486	37,863	75.2	75.2	82.8	83.4
Psychology	11,790	12,619	13,134	10,958	5,989	6,537	7,715	6,785	50.8	51.8	58.7	61.9
Social sciences	22,158	24,010	26,472	25,005	12,045	12,921	19,702	17,694	54.4	53.8	74.4	70.8
Engineering	12,809	14,079	17,656	18,660	9,562	8,692	14,198	15,201	74.7	61.7	80.4	81.5
Women												
Total science & engineering	16,649	19,538	32,619	35,599	9,761	11,981	23,625	25,207	58.6	61.3	72.4	70.8
Total sciences	16,555	19,412	32,120	34,934	9,687	11,883	23,182	24,588	58.5	61.2	72.2	70.4
Physical sciences	1,312	1,519	2,037	2,068	726	902	1,444	1,299	55.3	59.4	70.9	62.8
Mathematics	733	814	1,092	1,226	351	392	625	825	47.9	48.2	57.2	67.3
Computer sciences	105	164	444	690	67	95	333	467	63.8	57.9	75.0	67.7
Environmental sciences	249	316	646	726	175	242	580	653	70.3	76.6	89.8	89.9
Life sciences	6,955	8,039	14,626	16,418	4,908	5,915	11,583	12,586	70.6	73.6	79.2	76.7
Psychology	3,437	4,313	6,732	6,929	1,619	2,045	3,832	3,882	47.1	47.4	56.9	56.0
Social sciences	3,764	4,247	6,543	6,877	1,841	2,292	4,785	4,876	48.9	54.0	73.1	70.9
Engineering	94	126	499	665	74	98	443	619	78.7	77.8	88.8	93.1

NOTE: Academic institutions exclude university-administered federally funded research and development centers.

SOURCE: Science Resources Studies Division, National Science Foundation (NSF), *Characteristics of Doctoral Scientists and Engineers: 1991* (Washington, DC: NSF, forthcoming); and NSF, unpublished tabulations.

See figure 5–8.

Appendix table 5–15.

Doctoral scientists and engineers employed as academic faculty, by field and primary responsibility: 1973–91

(page 1 of 2)

	Total employment	Primary responsibility			
		R&D	Teaching	R&D	Teaching
	Number	Number		Percent	
Total science & engineering					
1973	97,980	22,239	66,601	23.0	69.0
1975	111,378	24,064	77,075	22.1	70.7
1977	118,559	28,676	74,759	24.5	63.9
1979	119,989	30,144	73,315	25.3	61.5
1981	130,388	32,042	84,821	24.8	65.6
1983	133,909	32,714	83,571	24.6	62.7
1985	144,663	38,469	87,382	27.0	61.3
1987	149,219	46,676	85,757	31.4	57.6
1989	154,300	49,326	86,510	32.1	56.3
1991	149,874	48,687	84,306	32.7	56.6
Total sciences					
1973	87,758	20,506	59,092	0.23	0.67
1975	100,111	22,217	68,820	0.22	0.69
1977	106,782	26,270	67,150	0.25	0.63
1979	107,872	27,835	65,398	0.26	0.61
1981	117,217	29,610	75,582	0.25	0.64
1983	120,023	30,115	74,455	0.25	0.62
1985	129,662	35,320	77,633	0.27	0.60
1987	133,265	42,189	76,516	0.32	0.57
1989	137,729	44,339	76,955	0.32	0.56
1991	132,393	43,707	73,568	0.33	0.56
Physical sciences					
1973	15,020	2,455	11,755	16.5	78.9
1975	17,032	3,146	12,943	18.8	77.4
1977	17,442	3,974	12,180	23.0	70.4
1979	17,400	4,032	11,888	23.3	68.6
1981	17,922	3,862	13,064	21.7	73.4
1983	17,873	4,159	11,897	23.4	66.8
1985	19,252	4,738	12,792	24.9	67.1
1987	19,192	5,438	12,755	28.4	66.6
1989	18,726	5,249	12,107	28.1	64.8
1991	17,555	5,103	11,554	29.2	66.1

	Total employment	Primary responsibility			
		R&D	Teaching	R&D	Teaching
	Number	Number		Percent	
Mathematics					
1973	8,622	1,316	6,797	15.5	79.8
1975	9,586	1,312	7,728	13.9	81.7
1977	10,020	1,428	7,788	14.3	78.1
1979	10,120	1,696	7,578	16.9	75.3
1981	10,258	1,464	8,015	14.3	78.5
1983	10,188	1,532	7,686	15.2	76.1
1985	10,822	1,863	7,876	17.4	73.6
1987	10,599	2,214	7,655	20.9	72.4
1989	10,873	2,361	7,781	21.8	71.8
1991	11,829	2,852	8,166	24.5	70.3
Computer sciences					
1973	1,130	200	805	17.7	71.2
1975	1,332	222	940	16.8	71.1
1977	1,498	286	979	19.5	66.7
1979	1,700	331	975	19.7	58.1
1981	1,975	366	1,336	18.5	67.6
1983	2,453	457	1,726	18.7	70.7
1985	3,043	559	2,117	18.8	71.1
1987	3,573	807	2,282	22.6	63.9
1989	4,233	1,109	2,704	26.2	63.9
1991	5,004	1,524	2,968	30.9	60.2
Environmental sciences					
1973	4,005	1,033	2,702	26.4	69.0
1975	4,445	1,104	3,052	25.5	70.4
1977	4,558	1,127	3,037	25.2	67.8
1979	4,059	1,288	2,426	31.7	59.8
1981	4,633	1,384	3,084	30.0	66.9
1983	4,576	1,295	2,770	28.3	60.6
1985	4,829	1,530	2,885	32.1	60.5
1987	4,911	1,729	2,861	35.3	58.5
1989	5,344	2,168	2,870	40.6	53.7
1991	5,203	1,989	2,984	38.7	58.1

(continued)

Appendix table 5–15.

Doctoral scientists and engineers employed as academic faculty, by field and primary responsibility: 1973–91

(page 2 of 2)

	Total employment	Primary responsibility			
		R&D	Teaching	R&D	Teaching
	Number	Number		Percent	
Life sciences					
1973	29,851	11,112	15,764	37.9	53.8
1975	33,073	11,793	17,902	36.6	55.6
1977	35,462	13,609	17,018	38.9	48.7
1979	36,840	14,756	16,488	40.3	45.1
1981	40,622	16,715	18,978	41.7	47.4
1983	42,804	17,298	19,366	40.7	45.6
1985	46,241	19,976	19,341	43.9	42.5
1987	48,460	23,790	18,058	49.3	37.4
1989	50,413	23,956	18,871	47.8	37.7
1991	47,729	23,797	16,961	50.1	35.7
Psychology					
1973	10,444	1,803	7,125	17.4	68.9
1975	12,507	1,651	9,193	13.4	74.5
1977	13,091	2,040	8,649	15.7	66.8
1979	13,187	2,200	8,224	16.8	62.7
1981	14,989	2,322	10,251	15.5	68.6
1983	14,703	2,194	9,628	15.0	65.7
1985	16,134	2,663	10,420	16.7	65.2
1987	16,884	3,151	11,101	18.7	65.8
1989	17,175	3,488	10,688	20.5	62.8
1991	15,115	3,041	9,290	20.3	61.9

	Total employment	Primary responsibility			
		R&D	Teaching	R&D	Teaching
	Number	Number		Percent	
Social sciences					
1973	18,686	2,587	14,144	14.1	77.1
1975	22,136	2,989	17,062	13.8	73.8
1977	24,711	3,806	17,499	15.7	72.2
1979	24,566	3,532	17,819	14.5	73.1
1981	26,818	3,497	20,854	13.2	78.7
1983	27,426	3,180	21,382	11.6	78.2
1985	29,341	3,991	22,202	13.9	77.3
1987	29,646	5,060	21,804	17.1	73.8
1989	30,965	6,008	21,934	19.5	71.2
1991	29,958	5,401	21,645	18.1	72.7
Engineering					
1973	10,222	1,733	7,509	17.1	74.2
1975	11,267	1,847	8,255	16.7	74.6
1977	11,777	2,406	7,609	20.6	65.1
1979	12,117	2,309	7,917	19.1	65.5
1981	13,171	2,432	9,239	18.5	70.4
1983	13,886	2,599	9,116	18.8	65.9
1985	15,001	3,149	9,749	21.3	66.0
1987	15,954	4,487	9,241	28.2	58.1
1989	16,571	4,987	9,555	30.1	57.8
1991	17,481	4,980	10,738	28.7	61.9

NOTES: Academic institutions exclude university-administered federally funded research and development centers. Faculty includes assistant, associate, and full professors; instructors; and lecturers. Percentages are based on the number of faculty with known work responsibility. The focus here on primary work responsibility is not meant to imply that people are either researchers or teachers. Survey respondents were asked to select their primary and secondary work activities based on the time devoted to each during a typical week. Respondents who listed teaching as their primary work responsibility often listed research as their secondary one, and vice versa. Research and teaching are closely intertwined, particularly in advanced graduate training.

SOURCES: Science Resources Studies Division, National Science Foundation (NSF), *Characteristics of Doctoral Scientists and Engineers: 1991* (Washington, DC: NSF, forthcoming); and NSF, unpublished tabulations.

See figure 5-9.

Science & Engineering Indicators – 1993

Appendix table 5–16.

Academic employment and R&D activity of doctoral scientists and engineers, by field, race/ethnicity, and sex: 1979, 1981, 1989, and 1991

(page 1 of 3)

Field and race/ethnicity	Total employment				Total with responsibility for R&D			
	1979	1981	1989	1991	1979	1981	1989	1991
				Total				
Total science & engineering								
White	127,249	136,984	162,105	153,493	82,595	87,526	122,792	114,882
Asian	4,604	6,340	9,768	15,132	3,630	4,977	8,572	13,105
Black	1,263	1,689	2,579	4,223	707	717	1,543	2,770
Hispanic	1,453	1,596	2,453	3,838	931	1,049	2,030	3,038
Native American	243	217	365	348	176	156	242	248
Physical sciences								
White	18,664	19,218	20,146	18,593	12,430	12,690	15,447	13,779
Asian	834	1,101	1,212	2,205	598	790	987	1,894
Black	122	146	251	381	90	*	194	196
Hispanic	220	275	302	513	157	200	247	348
Native American	*	*	78	*	*	*	*	*
Mathematics								
White	9,665	9,456	10,117	10,531	5,481	5,448	7,141	7,286
Asian	325	617	795	1,257	252	372	607	1,051
Black	108	131	121	155	51	52	69	104
Hispanic	105	142	112	372	71	85	86	287
Native American	*	*	*	*	*	*	*	*
Computer sciences								
White	1,837	2,352	4,390	4,999	1,193	1,461	2,951	3,353
Asian	106	124	290	863	96	112	199	733
Black	*	*	*	57	*	*	*	50
Hispanic	*	*	96	62	*	*	91	*
Native American	*	*	*	*	*	*	*	*
Environmental sciences								
White	4,666	5,321	6,018	6,171	3,569	4,029	5,368	5,422
Asian	*	79	223	235	*	54	204	215
Black	*	*	*	*	*	*	*	*
Hispanic	*	58	128	184	*	*	110	162
Native American	*	*	*	*	*	*	*	*
Life sciences								
White	41,791	45,177	56,792	54,151	30,861	33,624	46,278	43,770
Asian	1,610	2,463	3,598	5,056	1,444	2,193	3,195	4,559
Black	477	571	797	1,310	315	322	566	989
Hispanic	473	565	898	1,072	396	436	810	932
Native American	*	56	79	93	*	*	67	71
Psychology								
White	14,631	16,034	18,589	16,390	7,322	8,142	10,867	9,816
Asian	133	225	317	390	54	160	217	268
Black	219	318	519	726	86	99	216	380
Hispanic	99	159	311	321	65	81	172	163
Native American	*	*	*	*	*	*	*	*
Social sciences								
White	24,476	26,600	30,297	27,639	13,207	14,345	22,365	19,340
Asian	609	787	1,247	1,862	247	515	1,124	1,546
Black	307	447	788	1,360	157	169	444	859
Hispanic	215	204	393	811	123	114	331	675
Native American	96	68	132	129	59	*	81	97
Engineering								
White	11,519	12,826	15,756	15,019	8,532	7,787	12,375	12,116
Asian	951	944	2,086	3,264	906	781	2,039	2,839
Black	*	63	72	227	*	*	*	185
Hispanic	273	168	213	503	84	93	183	425
Native American	*	*	*	*	*	*	*	*

(continued)

Appendix table 5–16.

Academic employment and R&D activity of doctoral scientists and engineers, by field, race/ethnicity, and sex: 1979, 1981, 1989, and 1991

(page 2 of 3)

	Total employment				Total with responsibility for R&D			
Field and race/ethnicity	1979	1981	1989	1991	1979	1981	1989	1991
				Men				
Total science & engineering								
White	111,819	119,131	132,728	122,741	73,583	76,633	101,602	93,316
Asian	4,036	5,494	8,217	12,634	3,242	4,342	7,256	11,100
Black	912	1,189	1,665	2,846	533	472	1,013	1,834
Hispanic	1,273	1,384	1,844	3,025	812	913	1,567	2,422
Native American	225	201	298	268	159	141	191	202
Physical sciences								
White	17,493	17,871	18,360	16,990	11,790	11,898	14,196	12,803
Asian	723	974	1,032	1,860	530	706	853	1,651
Black	112	135	227	331	82	*	172	158
Hispanic	205	256	258	455	150	195	213	306
Native American	*	*	78	*	*	*	*	*
Mathematics								
White	9,003	8,725	9,177	9,565	5,165	5,087	6,628	6,648
Asian	267	559	680	1,065	219	347	522	916
Black	99	116	99	124	50	50	58	85
Hispanic	102	134	103	335	70	81	79	254
Native American	*	*	*	*	*	*	*	*
Computer sciences								
White	1,737	2,197	3,978	4,427	1,131	1,372	2,641	2,953
Asian	101	117	270	755	91	108	181	676
Black	*	*	*	*	*	*	*	*
Hispanic	*	*	89	62	*	*	89	*
Native American	*	*	*	*	*	*	*	*
Environmental sciences								
White	4,421	5,024	5,412	5,488	3,398	3,804	4,823	4,812
Asian	*	75	199	206	*	50	180	186
Black	*	*	*	*	*	*	*	*
Hispanic	*	51	118	177	*	*	103	155
Native American	*	*	*	*	*	*	*	*
Life sciences								
White	35,395	37,915	43,689	39,945	26,342	28,305	35,970	33,041
Asian	1,345	2,001	2,729	3,740	1,240	1,790	2,398	3,367
Black	295	369	433	841	218	209	337	657
Hispanic	398	479	664	731	337	375	613	649
Native American	*	*	*	54	*	*	*	51
Psychology								
White	11,398	12,041	12,465	10,167	5,796	6,235	7,368	6,326
Asian	84	123	170	236	*	100	105	196
Black	144	169	241	330	52	*	80	111
Hispanic	50	120	165	180	*	62	96	112
Native American	*	*	*	*	*	*	*	*
Social sciences								
White	20,935	22,642	24,323	21,675	11,493	12,231	17,990	15,106
Asian	543	712	1,095	1,577	204	469	1,015	1,338
Black	233	332	573	969	123	108	317	621
Hispanic	177	153	245	618	94	76	202	511
Native American	96	68	116	105	59	*	68	73
Engineering								
White	11,437	12,716	15,324	14,484	8,468	7,701	11,986	11,627
Asian	941	933	2,042	3,195	896	772	2,002	2,770
Black	*	63	65	202	*	*	*	160
Hispanic	273	166	202	467	84	91	172	389
Native American	*	*	*	*	*	*	*	*

(continued)

Appendix table 5–16.

Academic employment and R&D activity of doctoral scientists and engineers, by field, race/ethnicity, and sex: 1979, 1981, 1989, and 1991

(page 3 of 3)

Field and race/ethnicity	Total employment				Total with responsibility for R&D			
	1979	1981	1989	1991	1979	1981	1989	1991
				Women				
Total science & engineering								
White	15,430	17,853	29,377	30,752	9,012	10,893	21,190	21,566
Asian	568	846	1,551	2,498	388	635	1,316	2,005
Black	351	500	914	1,377	174	245	530	936
Hispanic	180	212	609	813	119	136	463	616
Native American	*	*	67	80	*	*	51	*
Physical sciences								
White	1,171	1,347	1,786	1,603	640	792	1,251	976
Asian	111	127	180	345	68	84	134	243
Black	*	*	*	50	*	*	*	*
Hispanic	*	*	*	58	*	*	*	*
Native American	*	*	*	*	*	*	*	*
Mathematics								
White	662	731	940	966	316	361	513	638
Asian	58	58	115	192	*	*	85	135
Black	*	*	*	*	*	*	*	*
Hispanic	*	*	*	*	*	*	*	*
Native American	*	*	*	*	*	*	*	*
Computer sciences								
White	100	155	412	572	62	89	310	400
Asian	*	*	*	108	*	*	*	57
Black	*	*	*	*	*	*	*	*
Hispanic	*	*	*	*	*	*	*	*
Native American	*	*	*	*	*	*	*	*
Environmental sciences								
White	245	297	606	683	171	225	545	610
Asian	*	*	*	*	*	*	*	*
Black	*	*	*	*	*	*	*	*
Hispanic	*	*	*	*	*	*	*	*
Native American	*	*	*	*	*	*	*	*
Life sciences								
White	6,396	7,262	13,103	14,206	4,519	5,319	10,308	10,729
Asian	265	462	869	1,316	204	403	797	1,192
Black	182	202	364	469	97	113	229	332
Hispanic	75	86	234	341	59	61	197	283
Native American	*	*	*	*	*	*	*	*
Psychology								
White	3,233	3,993	6,124	6,223	1,526	1,907	3,499	3,490
Asian	*	102	147	154	*	60	112	72
Black	75	149	278	396	*	55	136	269
Hispanic	*	*	146	141	*	*	76	51
Native American	*	*	*	*	*	*	*	*
Social sciences								
White	3,541	3,958	5,974	5,964	1,714	2,114	4,375	4,234
Asian	66	75	152	285	*	*	109	208
Black	74	115	215	391	*	61	127	238
Hispanic	*	51	148	193	*	*	129	164
Native American	*	*	*	*	*	*	*	*
Engineering								
White	82	110	432	535	64	86	389	489
Asian	*	*	*	69	*	*	*	69
Black	*	*	*	*	*	*	*	*
Hispanic	*	*	*	*	*	*	*	*
Native American	*	*	*	*	*	*	*	*

* = too few cases in survey to estimate population values

NOTES: Details cannot be aggregated to totals because of small sample sizes. Data reflect the composition of survey respondents whose field of employment, race/ethnicity, sex, and primary and secondary work responsibilities are known. Data are weighted estimates from sample surveys.Small numbers are subject to especially large variability and may not accurately reflect population patterns.

SOURCE: Science Resources Studies Division, National Science Foundation (NSF), *Characteristics of Doctoral Scientists and Engineers: 1991* (Washington, DC: NSF, forthcoming); and NSF, unpublished tabulations.

See text table 5–5.

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Appendix table 5–17.

Academic employment and R&D activity of doctoral scientists and engineers, by number of years since doctorate award and field: 1973–91

(page 1 of 3)

	Total employment					Active in R&D					Active in R&D				
	Years since doctorate					Years since doctorate					Years since doctorate				
	1–3	4–7	8–10	11–15	15+	1–3	4–7	8–10	11–15	15+	1–3	4–7	8–10	11–15	15+
	Number										Percent				
All science and engineering fields															
1973	21,816	26,249	14,266	15,449	29,743	17,221	20,653	10,869	11,296	20,908	78.9	78.7	76.2	73.1	70.3
1975	19,947	31,150	17,678	19,546	34,245	15,800	23,385	13,177	13,913	23,264	79.2	75.1	74.5	71.2	67.9
1977	18,606	31,240	19,769	23,241	37,639	12,919	20,546	12,959	14,327	23,120	69.4	65.8	65.6	61.6	61.4
1979	17,453	26,920	21,161	27,579	42,728	12,956	17,752	13,705	17,863	26,410	74.2	65.9	64.8	64.8	61.8
1981	17,287	26,383	20,844	32,456	50,817	13,491	18,365	13,197	19,605	30,230	78.0	69.6	63.3	60.4	59.5
1983	16,159	24,156	17,826	35,355	58,616	12,071	16,783	11,585	21,425	34,293	74.7	69.5	65.0	60.6	58.5
1985	16,885	25,128	18,819	35,276	71,203	12,537	17,424	12,411	20,772	42,009	74.2	69.3	65.9	58.9	59.0
1987	15,776	24,083	17,644	31,189	80,854	13,448	19,585	14,010	23,725	58,311	85.2	81.3	79.4	76.1	72.1
1989	16,912	23,603	17,925	29,998	89,536	14,311	20,121	14,309	23,165	63,843	84.6	85.2	79.8	77.2	71.3
1991	22,092	27,511	18,556	27,694	81,952	18,613	22,942	14,949	20,834	57,309	84.3	83.4	80.6	75.2	69.9
Physical sciences															
1973	3,029	4,183	2,362	2,696	5,032	2,484	3,316	1,885	2,115	3,529	82.0	79.3	79.8	78.4	70.1
1975	2,236	4,529	2,995	3,607	6,203	1,838	3,547	2,345	2,682	4,374	82.2	78.3	78.3	74.4	70.5
1977	2,183	4,010	3,112	3,894	6,909	1,867	2,766	2,153	2,526	4,573	85.5	69.0	69.2	64.9	66.2
1979	1,835	2,681	3,050	4,701	7,827	1,619	1,877	2,000	3,087	4,812	88.2	70.0	65.6	65.7	61.5
1981	1,835	2,635	2,185	5,218	9,062	1,647	2,143	1,498	3,142	5,457	89.8	81.3	68.6	60.2	60.2
1983	1,501	2,083	1,856	4,688	10,679	1,303	1,652	1,352	3,026	6,666	86.8	79.3	72.8	64.5	62.4
1985	1,760	2,111	1,825	3,968	13,287	1,542	1,716	1,417	2,316	8,296	87.6	81.3	77.6	58.4	62.4
1987	1,538	1,973	1,514	3,227	14,124	1,438	1,724	1,330	2,513	10,091	93.5	87.4	87.8	77.9	71.4
1989	1,966	1,940	1,443	2,649	14,225	1,872	1,826	1,259	2,061	10,089	95.2	94.1	87.2	77.8	70.9
1991	2,750	2,535	1,662	2,183	12,696	2,476	2,041	1,430	1,673	8,700	90.0	80.5	86.0	76.6	68.5
Mathematics															
1973	1,991	2,649	1,231	1,037	1,895	1,463	2,031	933	687	1,131	73.5	76.7	75.8	66.2	59.7
1975	1,492	3,116	1,561	1,516	2,127	1,073	2,209	1,145	1,110	1,284	71.9	70.9	73.4	73.2	60.4
1977	1,330	2,536	1,930	2,006	2,369	896	1,434	1,198	1,116	1,335	67.4	56.5	62.1	55.6	56.4
1979	947	1,803	2,013	2,673	2,877	798	868	1,136	1,602	1,541	84.3	48.1	56.4	59.9	53.6
1981	904	1,547	1,584	2,967	3,464	669	1,016	836	1,588	1,870	74.0	65.7	52.8	53.5	54.0
1983	815	1,379	1,140	2,859	4,267	630	963	584	1,520	2,300	77.3	69.8	51.2	53.2	53.9
1985	847	1,126	922	2,644	5,584	630	784	492	1,279	3,010	74.4	69.6	53.4	48.4	53.9
1987	716	1,298	858	1,881	6,111	630	1,095	651	1,366	4,018	88.0	84.4	75.9	72.6	65.8
1989	639	1,116	888	1,639	6,888	552	937	733	1,189	4,505	86.4	84.0	82.5	72.5	65.4
1991	1,357	1,596	1,392	1,668	6,329	1,118	1,402	1,042	1,373	3,815	82.4	87.8	74.9	82.3	60.3

(continued)

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Appendix table 5–17.

Academic employment and R&D activity of doctoral scientists and engineers, by number of years since doctorate award and field: 1973–91

(page 2 of 3)

	Total employment					Active in R&D					Active in R&D				
	Years since doctorate					Years since doctorate					Years since doctorate				
	1–3	4–7	8–10	11–15	15+	1–3	4–7	8–10	11–15	15+	1–3	4–7	8–10	11–15	15+
	Number										Percent				
Computer sciences															
1973	300	287	172	190	301	246	215	137	160	213	82.0	74.9	79.7	84.2	70.8
1975	338	363	173	218	373	256	231	82	172	295	75.7	63.6	47.4	78.9	79.1
1977	294	473	242	227	431	213	310	107	146	316	72.4	65.5	44.2	64.3	73.3
1979	240	579	429	322	410	182	344	302	203	274	75.8	59.4	70.4	63.0	66.8
1981	382	532	472	521	599	349	335	244	316	337	91.4	63.0	51.7	60.7	56.3
1983	375	762	449	720	889	209	462	246	315	545	55.7	60.6	54.8	43.7	61.3
1985	375	655	486	1,113	1,157	224	412	277	448	502	59.7	62.9	57.0	40.3	43.4
1987	398	506	488	962	1,823	344	443	327	563	1,077	86.4	87.5	67.0	58.5	59.1
1989	477	564	527	985	2,257	368	505	488	604	1,291	77.1	89.5	92.6	61.3	57.2
1991	967	1,007	380	1,151	2,579	891	845	269	740	1,485	92.1	83.9	70.8	64.3	57.6
Environmental sciences															
1973	886	1,097	618	648	1,284	785	844	505	536	875	88.6	76.9	81.7	82.7	68.1
1975	880	1,126	800	845	1,359	823	934	618	622	958	93.5	82.9	77.2	73.6	70.5
1977	739	1,258	730	1,019	1,508	679	1,055	515	701	1,025	91.9	83.9	70.5	68.8	68.0
1979	629	831	757	1,059	1,510	548	685	539	809	1,087	87.1	82.4	71.2	76.4	72.0
1981	745	856	857	1,162	1,863	727	722	656	784	1,247	97.6	84.3	76.5	67.5	66.9
1983	702	1,055	632	1,002	2,139	609	885	536	653	1,406	86.8	83.9	84.8	65.2	65.7
1985	502	892	661	1,180	2,538	435	741	563	885	1,707	86.7	83.1	85.2	75.0	67.3
1987	671	859	552	1,291	2,627	634	851	445	1,170	2,190	94.5	99.1	80.6	90.6	83.4
1989	604	937	680	1,126	3,059	588	902	603	1,057	2,566	97.4	96.3	88.7	93.9	83.9
1991	783	1,010	842	1,133	2,864	732	924	798	935	2,452	93.5	91.5	94.8	82.5	85.6
Life sciences															
1973	6,617	7,531	4,169	4,757	11,135	5,406	6,430	3,366	3,770	8,781	81.7	85.4	80.7	79.3	78.9
1975	6,301	9,324	4,813	5,690	11,754	5,216	7,508	3,890	4,446	8,749	82.8	80.5	80.8	78.1	74.4
1977	6,119	9,775	6,005	6,636	12,715	4,701	7,385	4,473	4,744	8,772	76.8	75.5	74.5	71.5	69.0
1979	6,076	9,483	6,716	7,938	14,403	5,001	7,258	4,993	5,778	10,213	82.3	76.5	74.3	72.8	70.9
1981	6,572	9,211	6,840	9,656	16,724	5,772	7,414	5,022	7,084	11,428	87.8	80.5	73.4	73.4	68.3
1983	6,583	8,639	6,166	11,811	18,430	5,561	6,677	4,598	8,379	12,355	84.5	77.3	74.6	70.9	67.0
1985	6,677	9,434	6,716	11,785	22,132	5,752	7,538	4,846	8,521	14,685	86.1	79.9	72.2	72.3	66.4
1987	6,320	9,679	6,546	10,772	24,934	5,616	8,223	5,665	8,857	19,146	88.9	85.0	86.5	82.2	76.8
1989	7,275	9,634	7,266	10,405	27,749	6,375	8,533	6,036	8,689	21,436	87.6	88.6	83.1	83.5	77.2
1991	8,496	10,645	7,537	10,164	24,985	7,280	9,093	6,487	8,218	19,371	85.7	85.4	86.1	80.9	77.5

(continued)

Appendix table 5–17.

Academic employment and R&D activity of doctoral scientists and engineers, by number of years since doctorate award and field: 1973–91

(page 3 of 3)

	Total employment					Active in R&D					Active in R&D				
	Years since doctorate					Years since doctorate					Years since doctorate				
	1–3	4–7	8–10	11–15	15+	1–3	4–7	8–10	11–15	15+	1–3	4–7	8–10	11–15	15+
	Number										Percent				
Psychology															
1973	2,477	2,910	1,469	1,674	2,693	1,837	1,948	970	1,013	1,614	74.2	66.9	66.0	60.5	59.9
1975	2,579	3,619	1,858	1,995	3,567	1,717	2,303	1,225	1,133	1,892	66.6	63.6	65.9	56.8	53.0
1977	2,555	3,651	1,953	2,302	3,688	1,359	2,011	1,081	1,096	1,726	53.2	55.1	55.4	47.6	46.8
1979	2,636	3,551	2,230	2,612	4,198	1,575	1,813	1,199	1,101	1,920	59.7	51.1	53.8	42.2	45.7
1981	2,246	3,717	2,579	3,344	5,046	1,297	2,064	1,359	1,612	2,250	57.7	55.5	52.7	48.2	44.6
1983	2,060	3,160	2,183	3,418	5,658	1,039	1,729	1,257	1,371	2,671	50.4	54.7	57.6	40.1	47.2
1985	2,482	3,387	2,516	3,803	6,785	1,165	1,568	1,235	1,774	2,953	46.9	46.3	49.1	46.6	43.5
1987	2,307	3,209	2,179	3,721	7,947	1,438	2,017	1,444	2,384	4,555	62.3	62.9	66.3	64.1	57.3
1989	2,188	2,932	2,105	3,722	8,919	1,317	1,723	1,312	2,101	5,094	60.2	58.8	62.3	56.4	57.1
1991	1,870	3,019	1,975	2,937	8,086	1,287	2,048	1,055	1,676	4,601	68.8	67.8	53.4	57.1	56.9
Social sciences															
1973	4,726	4,522	2,379	2,765	4,899	3,507	3,234	1,564	1,673	3,049	74.2	71.5	65.7	60.5	62.2
1975	4,813	6,333	3,056	3,246	5,758	3,766	4,497	1,995	1,965	3,554	78.2	71.0	65.3	60.5	61.7
1977	4,237	7,393	3,453	3,889	6,461	2,316	3,984	1,814	1,724	3,084	54.7	53.9	52.5	44.3	47.7
1979	4,200	6,005	4,245	4,566	6,906	2,477	3,283	2,376	2,520	3,230	59.0	54.7	56.0	55.2	46.8
1981	3,628	6,217	4,358	6,117	7,937	2,187	3,519	2,251	3,173	4,083	60.3	56.6	51.7	51.9	51.4
1983	3,159	5,409	4,210	6,826	9,629	1,993	3,156	2,237	3,289	4,215	63.1	58.3	53.1	48.2	43.8
1985	3,159	5,456	4,364	7,414	11,210	1,871	3,161	2,665	3,512	5,454	59.2	57.9	61.1	47.4	48.7
1987	2,668	4,517	4,240	6,662	13,322	2,263	3,472	3,024	4,734	9,247	84.8	76.9	71.3	71.1	69.4
1989	2,440	4,459	3,653	6,760	15,703	2,027	3,782	2,731	5,170	10,787	83.1	84.8	74.8	76.5	68.7
1991	3,455	4,906	3,224	5,836	14,461	2,618	4,019	2,523	3,950	9,460	75.8	81.9	78.3	67.7	65.4
Engineering															
1973	1,790	3,070	1,866	1,682	2,504	1,493	2,635	1,509	1,342	1,716	83.4	85.8	80.9	79.8	68.5
1975	1,308	2,740	2,422	2,429	3,104	1,111	2,156	1,877	1,783	2,158	84.9	78.7	77.5	73.4	69.5
1977	1,149	2,144	2,344	3,268	3,558	888	1,601	1,618	2,274	2,289	77.3	74.7	69.0	69.6	64.3
1979	890	1,987	1,721	3,708	4,597	756	1,624	1,160	2,763	3,333	84.9	81.7	67.4	74.5	72.5
1981	975	1,668	1,969	3,471	6,122	843	1,152	1,331	1,906	3,558	86.5	69.1	67.6	54.9	58.1
1983	964	1,669	1,190	4,031	6,925	727	1,259	775	2,872	4,135	75.4	75.4	65.1	71.2	59.7
1985	1,083	2,067	1,329	3,369	8,510	918	1,504	916	2,037	5,402	84.8	72.8	68.9	60.5	63.5
1987	1,158	2,042	1,267	2,673	9,966	1,085	1,760	1,124	2,138	7,987	93.7	86.2	88.7	80.0	80.1
1989	1,323	2,021	1,363	2,712	10,736	1,212	1,913	1,147	2,294	8,075	91.6	94.7	84.2	84.6	75.2
1991	2,414	2,793	1,544	2,622	9,952	2,211	2,570	1,345	2,269	7,425	91.6	92.0	87.1	86.5	74.6

SOURCE: Science Resources Studies Division, National Science Foundation (NSF), *Characteristics of Doctoral Scientists and Engineers: 1991* (Washington, DC: NSF, forthcoming); and NSF, unpublished tabulations.

See figure 5–10 and text table 5–6.

Appendix table 5–18.
Full-time graduate students in science and engineering supported by research assistantships, by support source and field: 1979–91
(page 1 of 3)

	Full-time graduate students						
	Total	Total with RAs	Federal RAs	Nonfederal RAs	Total with RAs	Federal RAs	Nonfederal RAs
	Number				Percent		
Total science and engineering							
1979	232,376	48,999	28,016	20,983	21.1	12.1	9.0
1980	238,868	51,594	29,329	22,265	21.6	12.3	9.3
1981	242,777	52,752	29,149	23,603	21.7	12.0	9.7
1982	245,378	52,563	28,293	24,270	21.4	11.5	9.9
1983	252,846	54,923	29,144	25,779	21.7	11.5	10.2
1984	254,735	57,771	29,457	28,314	22.7	11.6	11.1
1985	258,241	61,040	30,432	30,608	23.6	11.8	11.9
1986	267,075	66,071	32,747	33,324	24.7	12.3	12.5
1987	271,772	70,221	34,966	35,255	25.8	12.9	13.0
1988	276,225	74,568	36,741	37,827	27.0	13.3	13.7
1989	283,849	79,116	38,552	40,564	27.9	13.6	14.3
1990	288,981	79,595	38,022	41,573	27.5	13.2	14.4
1991	308,669	84,901	40,609	44,292	27.5	13.2	14.3
Physical sciences							
1979	22,535	7,806	6,512	1,294	34.6	28.9	5.7
1980	22,918	8,340	6,980	1,360	36.4	30.5	5.9
1981	23,308	8,607	7,271	1,336	36.9	31.2	5.7
1982	24,038	8,768	7,095	1,673	36.5	29.5	7.0
1983	25,205	9,145	7,471	1,674	36.3	29.6	6.6
1984	25,852	9,628	7,807	1,821	37.2	30.2	7.0
1985	26,669	10,284	8,065	2,219	38.6	30.2	8.3
1986	27,764	10,994	8,665	2,329	39.6	31.2	8.4
1987	28,414	11,558	8,873	2,685	40.7	31.2	9.4
1988	28,574	12,056	8,968	3,088	42.2	31.4	10.8
1989	29,207	12,426	9,145	3,281	42.5	31.3	11.2
1990	29,042	11,972	8,725	3,247	41.2	30.0	11.2
1991	30,131	12,223	8,881	3,342	40.6	29.5	11.1
Mathematics/computer sciences							
1979	15,520	1,642	1,005	637	10.6	6.5	4.1
1980	16,489	1,820	1,099	721	11.0	6.7	4.4
1981	17,599	1,858	1,055	803	10.6	6.0	4.6
1982	19,985	2,036	1,140	896	10.2	5.7	4.5
1983	21,644	2,206	1,193	1,013	10.2	5.5	4.7
1984	22,898	2,507	1,382	1,125	10.9	6.0	4.9
1985	25,919	3,074	1,551	1,523	11.9	6.0	5.9
1986	27,700	3,392	1,686	1,706	12.2	6.1	6.2
1987	28,616	3,948	2,142	1,806	13.8	7.5	6.3
1988	28,907	4,273	2,312	1,961	14.8	8.0	6.8
1989	29,492	4,643	2,445	2,198	15.7	8.3	7.5
1990	30,693	4,673	2,398	2,275	15.2	7.8	7.4
1991	30,811	4,897	2,596	2,301	15.9	8.4	7.5

(continued)

Appendix table 5–18

Full-time graduate students in science and engineering supported by research assistantships, by support source and field: 1979–91

(page 2 of 3)

	Full-time graduate students						
	Total	Total with RAs	Federal RAs	Nonfederal RAs	Total with RAs	Federal RAs	Nonfederal RAs
	Number				Percent		
				Environmental sciences			
1979	10,724	3,587	2,706	881	33.4	25.2	8.2
1980	10,969	3,770	2,702	1,068	34.4	24.6	9.7
1981	11,038	3,469	2,402	1,067	31.4	21.8	9.7
1982	11,436	3,339	2,323	1,016	29.2	20.3	8.9
1983	12,068	3,545	2,348	1,197	29.4	19.5	9.9
1984	11,837	3,583	2,328	1,255	30.3	19.7	10.6
1985	11,458	3,728	2,410	1,318	32.5	21.0	11.5
1986	11,347	3,838	2,372	1,466	33.8	20.9	12.9
1987	10,543	3,660	2,251	1,409	34.7	21.4	13.4
1988	10,299	3,892	2,317	1,575	37.8	22.5	15.3
1989	10,143	4,169	2,482	1,687	41.1	24.5	16.6
1990	10,273	4,153	2,445	1,708	40.4	23.8	16.6
1991	10,414	4,356	2,539	1,819	41.8	24.4	17.5
				Life sciences			
1979	70,966	15,412	7,222	8,190	21.7	10.2	11.5
1980	71,957	15,896	7,628	8,268	22.1	10.6	11.5
1981	71,931	16,344	7,593	8,751	22.7	10.6	12.2
1982	69,953	16,223	7,275	8,948	23.2	10.4	12.8
1983	69,696	16,496	7,260	9,236	23.7	10.4	13.3
1984	70,230	17,576	7,387	10,189	25.0	10.5	14.5
1985	69,509	17,896	7,989	9,907	25.7	11.5	14.3
1986	70,661	19,220	8,562	10,658	27.2	12.1	15.1
1987	71,456	20,225	9,344	10,881	28.3	13.1	15.2
1988	73,039	21,582	10,042	11,540	29.5	13.7	15.8
1989	75,452	23,183	10,930	12,253	30.7	14.5	16.2
1990	74,936	23,403	10,902	12,501	31.2	14.5	16.7
1991	82,938	25,674	12,060	13,614	31.0	14.5	16.4
				Psychology			
1979	25,859	2,528	1,170	1,358	9.8	4.5	5.3
1980	26,678	2,570	942	1,628	9.6	3.5	6.1
1981	26,715	2,890	1,036	1,854	10.8	3.9	6.9
1982	25,812	2,723	927	1,796	10.5	3.6	7.0
1983	26,693	2,962	944	2,018	11.1	3.5	7.6
1984	26,102	3,027	962	2,065	11.6	3.7	7.9
1985	25,751	3,078	1,017	2,061	12.0	3.9	8.0
1986	26,469	3,114	1,021	2,093	11.8	3.9	7.9
1987	27,308	3,218	1,078	2,140	11.8	3.9	7.8
1988	28,366	3,733	1,210	2,523	13.2	4.3	8.9
1989	29,608	3,866	1,278	2,588	13.1	4.3	8.7
1990	30,694	4,051	1,326	2,725	13.2	4.3	8.9
1991	32,382	4,275	1,459	2,816	13.2	4.5	8.7

(continued)

Appendix table 5–18.
Full-time graduate students in science and engineering supported by research assistantships, by support source and field: 1979–91
(page 3 of 3)

	Full-time graduate students						
	Total	Total with RAs	Federal RAs	Nonfederal RAs	Total with RAs	Federal RAs	Nonfederal RAs
	Number				Percent		
Social sciences							
1979	46,755	5,207	1,403	3,804	11.1	3.0	8.1
1980	47,137	5,275	1,444	3,831	11.2	3.1	8.1
1981	46,335	5,196	1,267	3,929	11.2	2.7	8.5
1982	44,289	4,866	971	3,895	11.0	2.2	8.8
1983	43,609	5,032	933	4,099	11.5	2.1	9.4
1984	42,659	5,166	916	4,250	12.1	2.1	10.0
1985	42,997	5,080	974	4,106	11.8	2.3	9.5
1986	42,907	5,101	885	4,216	11.9	2.1	9.8
1987	43,550	5,465	917	4,548	12.5	2.1	10.4
1988	43,853	5,580	921	4,659	12.7	2.1	10.6
1989	45,401	6,227	1,013	5,214	13.7	2.2	11.5
1990	47,651	6,257	1,073	5,184	13.1	2.3	10.9
1991	50,763	6,711	1,164	5,547	13.2	2.3	10.9
Engineering							
1979	40,017	12,817	7,998	4,819	32.0	20.0	12.0
1980	42,720	13,923	8,534	5,389	32.6	20.0	12.6
1981	45,851	14,388	8,525	5,863	31.4	18.6	12.8
1982	49,865	14,608	8,562	6,046	29.3	17.2	12.1
1983	53,931	15,537	8,995	6,542	28.8	16.7	12.1
1984	55,157	16,284	8,675	7,609	29.5	15.7	13.8
1985	55,938	17,900	8,426	9,474	32.0	15.1	16.9
1986	60,227	20,412	9,556	10,856	33.9	15.9	18.0
1987	61,885	22,147	10,361	11,786	35.8	16.7	19.0
1988	63,187	23,452	10,971	12,481	37.1	17.4	19.8
1989	64,546	24,602	11,259	13,343	38.1	17.4	20.7
1990	65,692	25,086	11,153	13,933	38.2	17.0	21.2
1991	71,230	26,763	11,910	14,853	37.6	16.7	20.9

RA = research assistantship

SOURCE: Science Resources Studies Division, National Science Foundation (NSF), *Academic Science and Engineering: Graduate Enrollment and Support, Fall 1991*, NSF 93-309 (Washington, DC: NSF, 1993); and NSF, unpublished tabulations.

See figure 5–11.

Science & Engineering Indicators – 1993

Appendix table 5-19.

Academic researchers reporting federal support, by number of years since doctorate award and field: 1973–91

(page 1 of 2)

	All researchers	Years since doctorate					All researchers	Years since doctorate				
		1–3	4–7	8–10	11–15	15+		1–3	4–7	8–10	11–15	15+
	Number						Percent					
All science and engineering fields												
1973	43,046	8,721	10,814	5,664	6,279	11,568	53.2	50.6	52.4	52.1	55.6	55.3
1975	44,198	7,403	11,303	6,651	6,967	11,874	49.4	46.9	48.3	50.5	50.1	51.0
1977	44,474	6,829	10,701	6,942	7,718	12,284	53.0	52.9	52.1	53.6	53.9	53.1
1979	46,419	7,213	9,505	6,800	9,172	13,729	52.3	55.7	53.5	49.6	51.3	52.0
1981	48,442	7,988	9,866	6,561	9,665	14,362	51.1	59.2	53.7	49.7	49.3	47.5
1983	55,139	7,310	10,142	6,824	12,242	18,621	57.3	60.6	60.4	58.9	57.1	54.3
1985	48,181	6,029	8,244	6,061	9,797	18,050	45.8	48.1	47.3	48.8	47.2	43.0
1987	73,875	7,801	11,992	8,624	14,060	31,398	57.2	58.0	61.2	61.6	59.3	53.8
1989	80,398	9,213	12,876	9,063	14,456	34,790	59.2	64.4	64.0	63.3	62.4	54.5
1991	77,786	10,491	13,990	9,592	12,925	30,788	57.8	56.4	61.0	64.2	62.0	53.7
Physical sciences												
1973	7,093	1,635	1,572	973	1,123	1,790	53.2	65.8	47.4	51.6	53.1	50.7
1975	7,593	1,191	1,764	1,153	1,251	2,234	51.4	64.8	49.7	49.2	46.6	51.1
1977	7,504	1,267	1,532	1,075	1,312	2,318	54.0	67.9	55.4	49.9	51.9	50.7
1979	7,332	1,114	934	955	1,755	2,574	54.7	68.8	49.8	47.7	56.9	53.5
1981	7,989	1,223	1,258	925	1,629	2,954	57.5	74.3	58.7	61.7	51.8	54.1
1983	8,791	967	1,173	938	1,829	3,884	62.8	74.2	71.0	69.4	60.4	58.3
1985	7,720	1,006	858	802	1,060	3,994	50.5	65.2	50.0	56.6	45.8	48.1
1987	10,921	1,065	1,142	952	1,792	5,970	63.9	74.1	66.2	71.6	71.3	59.2
1989	11,547	1,516	1,277	910	1,344	6,500	67.5	81.0	69.9	72.3	65.2	64.4
1991	10,635	1,737	1,414	866	1,306	5,312	65.2	70.2	69.3	60.6	78.1	61.1
Mathematics												
1973	1,972	310	647	240	293	482	31.6	21.2	31.9	25.7	42.6	42.6
1975	1,483	108	458	334	259	324	21.7	10.1	20.7	29.2	23.3	25.2
1977	1,206	136	255	308	224	283	20.2	15.2	17.8	25.7	20.1	21.2
1979	1,342	144	357	219	237	385	22.6	18.0	41.1	19.3	14.8	25.0
1981	1,360	101	297	192	476	294	22.7	15.1	29.2	23.0	30.0	15.7
1983	2,318	265	376	286	602	789	38.7	42.1	39.0	49.0	39.6	34.3
1985	1,518	83	232	180	324	699	24.5	13.2	29.6	36.6	25.3	23.2
1987	2,675	147	396	276	511	1,345	34.5	23.3	36.2	42.4	37.4	33.5
1989	2,892	160	374	319	549	1,490	36.5	29.0	39.9	43.5	46.2	33.1
1991	3,276	423	564	531	549	1,209	37.4	37.8	40.2	51.0	40.0	31.7
Computer sciences												
1973	533	120	147	76	107	83	54.9	46.8	68.4	55.5	66.9	39.0
1975	425	79	110	37	84	115	41.0	30.9	47.6	45.1	48.8	39.0
1977	594	107	200	59	84	144	54.4	50.2	64.5	55.1	57.5	45.6
1979	574	80	202	138	47	107	44.0	44.0	58.7	45.7	23.2	39.1
1981	736	175	165	143	125	128	46.6	50.1	49.3	58.6	39.6	38.0
1983	920	150	307	122	128	213	51.8	71.8	66.5	49.6	40.6	39.1
1985	680	55	155	129	171	170	36.5	24.6	37.6	46.6	38.2	33.9
1987	1,526	185	296	229	248	568	55.4	53.8	66.8	70.0	44.0	52.7
1989	1,646	111	375	326	310	524	50.6	30.2	74.3	66.8	51.3	40.6
1991	2,047	287	506	163	461	630	48.4	32.2	59.9	60.6	62.3	42.4
Environmental sciences												
1973	2,139	484	564	272	338	481	60.3	61.7	66.8	53.9	63.1	55.0
1975	2,339	502	591	385	370	483	59.1	61.0	63.3	62.3	60.8	50.4
1977	2,287	321	653	336	390	587	57.5	47.3	61.9	65.2	55.6	57.3
1979	2,317	465	461	327	494	570	63.2	84.9	67.3	60.7	61.1	52.4
1981	2,425	443	494	385	389	714	58.6	60.9	68.4	58.7	49.6	57.3
1983	2,720	456	599	423	392	850	66.5	74.9	67.7	78.9	60.0	60.5
1985	2,587	273	499	352	579	884	59.7	62.8	67.3	62.5	65.4	51.8
1987	3,613	424	603	349	874	1,363	68.3	66.9	79.9	78.4	74.7	62.2
1989	4,096	369	747	495	879	1,606	71.7	62.8	82.8	82.1	83.2	62.6
1991	4,396	564	814	684	834	1,500	75.3	77.0	88.1	85.7	89.2	61.2

(continued)

Appendix table 5–19.
Academic researchers reporting federal support, by number of years since doctorate award and field: 1973–91
(page 2 of 2)

	All researchers	Years since doctorate					All researchers	Years since doctorate				
		1–3	4–7	8–10	11–15	15+		1–3	4–7	8–10	11–15	15+
	Number						Percent					
Life sciences												
1973	18,645	3,717	4,323	2,281	2,452	5,872	67.2	68.8	67.2	67.8	65.0	66.9
1975	19,322	3,469	4,787	2,578	2,911	5,577	64.8	66.5	63.8	66.3	65.5	63.7
1977	20,522	3,315	5,052	3,126	3,282	5,747	68.2	70.5	68.4	69.9	69.2	65.5
1979	21,743	3,482	4,790	3,237	3,766	6,468	65.4	69.6	66.0	64.8	65.2	63.3
1981	23,194	4,355	4,872	3,119	4,287	6,561	63.2	75.5	65.7	62.1	60.5	57.4
1983	25,954	3,961	4,886	3,344	5,805	7,958	69.1	71.2	73.2	72.7	69.3	64.4
1985	24,442	3,481	4,781	3,012	5,179	7,989	59.1	60.5	63.4	62.2	60.8	54.4
1987	34,420	4,093	6,254	4,529	6,695	12,849	72.5	72.9	76.1	79.9	75.6	67.1
1989	37,488	5,056	6,464	4,668	6,876	14,424	73.4	79.3	75.8	77.3	79.1	67.3
1991	36,386	5,167	6,663	5,180	6,146	13,230	72.1	71.0	73.3	79.9	74.8	68.3
Psychology												
1973	3,296	751	861	383	456	845	44.6	40.9	44.2	39.5	45.0	52.4
1975	3,336	558	940	459	483	896	40.3	32.5	40.8	37.5	42.6	47.4
1977	2,838	465	750	376	485	762	39.0	34.2	37.3	34.8	44.3	44.1
1979	3,129	724	784	456	353	812	41.1	46.0	43.2	38.0	32.1	42.3
1981	3,261	719	838	438	468	798	38.0	55.4	40.6	32.2	29.0	35.5
1983	3,001	355	652	566	477	951	37.2	34.2	37.7	45.0	34.8	35.6
1985	2,866	483	594	499	474	816	33.0	41.5	37.9	40.4	26.7	27.6
1987	4,358	708	708	668	776	1,498	36.8	49.2	35.1	46.3	32.6	32.9
1989	4,797	670	700	482	1,104	1,841	41.5	50.9	40.6	36.7	52.5	36.1
1991	4,104	490	854	324	799	1,637	38.5	38.1	41.7	30.7	47.7	35.6
Social sciences												
1973	4,094	944	1,139	536	543	932	31.4	26.9	35.2	34.3	32.5	30.6
1975	4,410	834	1,344	677	539	1,016	28.0	22.1	29.9	33.9	27.4	28.6
1977	4,180	661	1,265	650	611	993	32.3	28.5	31.8	35.8	35.4	32.2
1979	4,266	766	953	776	907	864	30.7	30.9	29.0	32.7	36.0	26.7
1981	4,270	552	1,084	530	1,029	1,075	28.1	25.2	30.8	23.5	32.4	26.3
1983	4,962	783	1,268	572	1,133	1,206	33.3	39.3	40.2	25.6	34.4	28.6
1985	3,534	280	638	431	871	1,314	21.2	15.0	20.2	16.2	24.8	24.1
1987	7,126	547	1,342	842	1,675	2,720	31.3	24.2	38.7	27.8	35.4	29.4
1989	8,138	583	1,385	1,101	1,674	3,395	33.2	28.8	36.6	40.3	32.4	31.5
1991	6,473	427	1,316	906	1,304	2,520	28.7	16.3	32.7	35.9	33.0	26.6
Engineering												
1973	5,274	760	1,561	903	967	1,083	60.7	50.9	59.2	59.8	72.1	63.1
1975	5,290	662	1,309	1,028	1,062	1,229	58.2	59.6	60.7	54.8	59.6	57.0
1977	5,343	557	994	1,012	1,330	1,450	61.6	62.7	62.1	62.5	58.5	63.3
1979	5,716	438	1,024	692	1,613	1,949	59.3	57.9	63.1	59.7	58.4	58.5
1981	5,207	420	858	829	1,262	1,838	59.2	49.8	74.5	62.3	66.2	51.7
1983	6,473	373	881	573	1,876	2,770	66.3	51.3	70.0	73.9	65.3	67.0
1985	4,834	368	487	656	1,139	2,184	44.9	40.1	32.4	71.6	55.9	40.4
1987	9,236	632	1,251	779	1,489	5,085	65.5	58.2	71.1	69.3	69.6	63.7
1989	9,794	748	1,554	762	1,720	5,010	66.9	61.7	81.2	66.4	75.0	62.0
1991	10,469	1,396	1,859	938	1,526	4,750	66.2	63.1	72.3	69.7	67.3	64.0

SOURCE: Science Resources Studies Division, National Science Foundation (NSF), *Characteristics of Doctoral Scientists and Engineers: 1991* (Washington, DC: NSF, forthcoming); and NSF, unpublished tabulations.

See figure 5–12.

Appendix table 5–20.

Federally supported academic doctorate-holders, by field of employment and number of funders: 1979–91

Field	1979	1981	1983	1985	1987	1989	1991
Total							
Total science & engineering	53,270	54,514	64,231	54,534	81,856	88,371	86,429
Physical sciences	8,085	8,638	9,779	8,272	11,665	12,366	11,609
Mathematics	1,693	1,668	2,641	1,738	3,039	3,262	3,724
Computer sciences	690	893	1,145	834	1,693	1,789	2,612
Environmental sciences	2,472	2,564	2,998	2,789	3,751	4,249	4,609
Life sciences	24,282	25,016	29,049	27,004	37,609	40,319	39,123
Psychology	4,338	4,209	3,902	3,591	5,457	6,131	5,068
Social sciences	5,324	5,607	6,768	4,485	8,597	9,424	8,123
Engineering	6,386	5,919	7,949	5,821	10,045	10,831	11,561
Supported by one federal agency							
Total science & engineering	42,950	43,498	50,504	43,629	60,182	64,984	61,287
Physical sciences	6,313	6,407	7,415	6,262	8,103	8,462	7,856
Mathematics	1,517	1,499	2,341	1,483	2,431	2,479	2,931
Computer sciences	568	659	790	635	1,129	982	1,683
Environmental sciences	1,602	1,547	1,517	1,643	1,905	2,227	2,195
Life sciences	20,235	20,909	23,503	22,402	28,830	31,240	29,812
Psychology	3,653	3,435	3,275	2,922	4,592	4,974	4,157
Social sciences	4,711	4,631	5,952	3,972	6,790	7,674	5,968
Engineering	4,351	4,411	5,711	4,310	6,402	6,946	6,685
Supported by more than one federal agency							
Total science & engineering	9,830	10,478	13,229	10,239	21,236	23,234	24,564
Physical sciences	1,718	2,173	2,308	1,907	3,473	3,860	3,663
Mathematics	155	157	286	227	540	766	700
Computer sciences	122	208	346	178	564	807	929
Environmental sciences	831	995	1,458	1,145	1,826	2,008	2,382
Life sciences	3,837	3,852	5,234	4,318	8,597	9,013	9,129
Psychology	607	727	569	573	810	1,155	888
Social sciences	563	904	790	438	1,799	1,750	2,016
Engineering	1,997	1,462	2,238	1,453	3,627	3,875	4,857

NOTES: Data exclude university-administered federally funded research and development centers. Data are limited to respondents with doctorates in science and engineering (S&E) from a U.S. academic institution; data exclude non-S&E doctorate-holders working in S&E and persons with S&E doctorates awarded by foreign institutions. For a fuller discussion, see chapter 5, "Changes in the Survey of Doctorate Recipients." Details do not sum to totals because some academic doctorate-holders do not specify agencies providing support.

SOURCE: Science Resources Studies Division, National Science Foundation, Survey of Doctorate Recipients, unpublished tabulations.

See figure 5–13.

Science & Engineering Indicators – 1993

Appendix table 5–21.

U.S. and world scientific and technical articles, by field: 1973–91

Field	1973	1975	1977	1979	1981	1983	1985	1987	1989	1991
	Article publication year									
Total number of articles										
All fields	271,512	260,908	263,700	267,954	368,934	373,550	389,845	378,312	403,845	405,554
Clinical medicine	76,209	73,485	77,597	78,827	116,371	119,325	125,532	124,975	130,106	130,107
Biomedical research	41,155	41,244	41,388	43,631	55,303	57,289	64,717	64,216	68,616	69,205
Biology	24,047	23,260	23,757	24,734	39,232	37,788	34,896	32,775	34,199	34,233
Chemistry	45,004	42,502	40,734	43,273	54,432	54,186	55,268	53,236	56,126	56,731
Physics	35,864	35,104	36,057	36,700	45,561	46,902	54,044	53,377	61,449	60,758
Earth and space sciences	11,977	11,356	11,531	11,596	16,991	16,508	17,834	18,285	18,714	19,509
Engineering and technology	28,617	25,664	25,063	22,182	30,710	32,073	28,004	24,344	25,442	27,618
Mathematics	8,639	8,293	7,573	7,011	10,334	9,478	9,551	7,105	9,193	7,393
Number of U.S. articles										
All fields	103,778	97,278	97,854	99,377	132,279	132,415	137,771	134,497	140,833	142,333
Clinical medicine	32,638	31,334	33,516	33,975	48,072	48,055	50,595	49,904	50,510	50,142
Biomedical research	16,115	15,901	16,197	17,649	21,847	22,496	24,461	24,542	26,541	26,918
Biology	11,150	10,400	9,904	10,553	14,740	14,216	13,083	12,231	12,726	12,862
Chemistry	10,474	9,222	8,852	9,182	10,880	11,010	11,585	11,827	12,405	13,086
Physics	11,721	11,363	10,995	10,995	13,053	13,021	15,903	16,078	17,649	18,077
Earth and space sciences	5,591	4,975	5,197	5,167	7,257	6,862	7,663	7,797	7,770	8,138
Engineering and technology	11,955	10,431	10,081	9,018	12,486	13,105	10,822	9,225	9,568	9,999
Mathematics	4,134	3,652	3,112	2,838	3,943	3,648	3,659	2,893	3,664	3,111
U.S. articles as a percentage of all articles										
All fields	38.2	37.3	37.1	37.1	35.9	35.4	35.3	35.6	34.9	35.1
Clinical medicine	42.8	42.6	43.2	43.1	41.3	40.3	40.3	39.9	38.8	38.5
Biomedical research	39.2	38.6	39.1	40.5	39.5	39.3	37.8	38.2	38.7	38.9
Biology	46.4	44.7	41.7	42.7	37.6	37.6	37.5	37.3	37.2	37.6
Chemistry	23.3	21.7	21.7	21.2	20.0	20.3	21.0	22.2	22.1	23.1
Physics	32.7	32.4	30.5	30.0	28.7	27.8	29.4	30.1	28.7	29.8
Earth and space sciences	46.7	43.8	45.1	44.6	42.7	41.6	43.0	42.6	41.5	41.7
Engineering and technology	41.8	40.6	40.2	40.7	40.7	40.9	38.6	37.9	37.6	36.2
Mathematics	47.9	44.0	41.1	40.5	38.2	38.5	38.3	40.7	39.9	42.1

NOTES: Articles written by researchers from more than one country are prorated according to the number of author institutions in each country. For example, a paper authored by two U.S. and one French scientist would be counted as two-thirds of a U.S. article and one-third of a French article. Data for 1973–80 are based on more than 2,100 journals carried on the 1973 Science Citation Index Corporate Tapes of the Institute for Scientific Information. Data for 1981–91 are based on more than 3,500 U.S. and foreign journals on the 1981 Science Citation Index Corporate Tapes.

SOURCE: CHI Research, Inc., *Science & Engineering Indicators* Literature Database, special tabulations, 1993.

See figures 5–14 and 5–17.

Science & Engineering Indicators – 1993

Appendix table 5–22.
Scientific and technical fields in which the U.S. share of world publications changed by more than 5 percentage points: 1981–91

Field	World publications published in			U.S. publications published in			U.S. share of world articles			Net change 1981–91
	1981	1986	1991	1981	1986	1991	1981	1986	1991	
	Number			Number			Percent			
Gains in U.S. share										
General engineering	1,282	317	308	238	158	109	18.6	49.8	35.4	16.8
Biophysics	978	1,151	820	281	435	336	28.7	37.8	41.0	12.2
General biology	1,735	504	593	588	142	266	33.9	28.2	44.9	11.0
Applied mathematics	2,010	1,551	1,577	704	679	725	35.0	43.8	46.0	10.9
Aerospace technology	933	913	844	556	540	581	59.6	59.1	68.8	9.2
Oceanography & limnology	1,451	1,162	1,218	594	523	611	40.9	45.0	50.2	9.2
General chemistry	15,772	15,472	14,570	2,135	3,075	3,196	13.5	19.9	21.9	8.4
Nutrition & dietetics	1,943	1,507	1,484	880	797	781	45.3	52.9	52.6	7.3
Applied chemistry	2,660	1,504	1,422	470	303	355	17.7	20.1	25.0	7.3
Misc. clinical medicine	332	458	543	201	295	367	60.5	64.4	67.6	7.0
Physiology	3,564	4,801	5,501	1,518	2,299	2,692	42.6	47.9	48.9	6.3
Microscopy	603	428	404	148	158	124	24.5	36.9	30.7	6.1
General zoology	2,011	2,141	1,901	354	514	448	17.6	24.0	23.6	6.0
General mathematics	5,344	4,549	4,284	1,728	1,689	1,638	32.3	37.1	38.2	5.9
Operations research & mgmt science	759	348	367	309	169	169	40.7	48.6	46.0	5.3
Applied physics	10,104	12,573	16,035	2,887	4,077	5,393	28.6	32.4	33.6	5.1
Losses in U.S. share										
Hematology	2,269	2,858	3,163	897	1,023	1,089	39.5	35.8	34.4	(5.1)
Allergy	671	820	745	292	325	286	43.5	39.6	38.4	(5.1)
Endocrinology	4,361	4,791	4,635	1,870	1,788	1,745	42.9	37.3	37.6	(5.2)
Urology	1,765	1,636	1,815	842	801	770	47.7	49.0	42.4	(5.3)
Optics	2,079	2,515	3,052	830	1,017	1,056	39.9	40.4	34.6	(5.3)
Acoustics	1,330	1,243	1,242	613	483	504	46.1	38.9	40.6	(5.5)
Astronomy & astrophysics	4,325	4,329	4,467	1,986	1,746	1,775	45.9	40.3	39.7	(6.2)
Civil engineering	2,055	712	696	1,205	385	363	58.6	54.1	52.2	(6.5)
Embryology	997	669	844	478	198	347	47.9	29.6	41.1	(6.8)
Environmental science[1]	NA	3,361	3,920	NA	1,594	1,588	NA	47.4	40.5	(6.9)
Miscellaneous mathematics	1,431	533	448	710	202	190	49.6	37.9	42.4	(7.2)
Dentistry	2,225	2,613	2,727	1,106	1,154	1,153	49.7	44.2	42.3	(7.4)
Nuclear & particle physics	3,216	5,944	7,217	1,255	1,962	2,263	39.0	33.0	31.4	(7.7)
Marine biology & hydrobiology	3,350	3,780	4,099	1,215	1,160	1,161	36.3	30.7	28.3	(7.9)
Miscellaneous biomedicine	1,544	1,134	1,145	759	486	462	49.2	42.9	40.3	(8.8)
Addictive diseases	492	476	600	330	276	349	67.1	58.0	58.2	(8.9)
Misc. engineering/technology	782	611	521	280	162	139	35.8	26.5	26.7	(9.1)
Tropical medicine	836	772	855	203	141	128	24.3	18.3	15.0	(9.3)
Pharmacy	4,154	2,753	2,438	1,129	536	406	27.2	19.5	16.7	(10.5)
Biomedical engineering	1,359	1,729	2,032	524	491	520	38.6	28.4	25.6	(13.0)
Anatomy & morphology	778	823	750	311	253	202	40.0	30.7	26.9	(13.0)
Cancer	5,374	6,691	7,302	2,785	2,916	2,785	51.8	43.6	38.1	(13.7)
Nephrology	573	724	765	271	265	250	47.3	36.6	32.7	(14.6)
Chemical engineering	2,793	3,290	3,344	1,338	1,294	1,080	47.9	39.3	32.3	(15.6)
Fluids & plasmas	1,107	1,192	797	603	645	300	54.5	54.1	37.6	(16.8)
Library & information science	223	31	26	128	20	10	57.4	64.5	38.5	(18.9)
Nuclear technology	2,839	1,943	1,995	1,474	872	531	51.9	44.9	26.6	(25.3)

NA = not available

[1] The net change for environmental science is from 1986 to 1991, as data for previous years are unavailable.

SOURCE: CHI Research, Inc., *Science & Engineering Indicators* Literature Database, special tabulations, 1993.

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Appendix table 5-23.

Country shares of world scientific and technical literature, by field: 1981–91

(page 1 of 3)

Field	Article publication year										
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Percent										
United States											
All fields	35.9	35.9	35.4	35.4	35.3	35.6	35.6	35.1	34.9	34.8	35.1
Clinical medicine	41.3	41.1	40.3	40.9	40.3	40.0	39.9	39.7	38.8	38.8	38.5
Biomedical research	39.5	39.7	39.3	39.5	37.8	38.4	38.2	38.4	38.7	38.8	38.9
Biology	37.6	38.4	37.6	37.2	37.5	38.1	37.3	37.0	37.2	37.0	37.6
Chemistry	20.0	21.2	20.3	20.6	21.0	22.2	22.2	22.2	22.1	22.0	23.1
Physics	28.7	28.1	27.8	27.3	29.4	30.3	30.1	28.8	28.7	28.4	29.8
Earth and space sciences	42.7	42.4	41.6	41.3	43.0	42.6	42.6	43.8	41.5	40.8	41.7
Engineering and technology	40.7	40.6	40.9	39.5	38.6	37.3	37.9	37.3	37.6	37.9	36.2
Mathematics	38.2	39.0	38.5	37.2	38.3	40.3	40.7	40.8	39.9	41.8	42.1
United Kingdom											
All fields	8.3	8.3	8.4	8.2	8.3	8.2	8.0	7.7	7.6	7.6	7.5
Clinical medicine	9.8	9.6	9.9	9.8	10.5	10.4	10.0	9.9	10.0	10.0	9.9
Biomedical research	8.5	8.7	8.8	8.3	8.2	8.0	7.6	7.4	7.4	7.5	7.6
Biology	9.0	8.8	9.1	9.1	8.8	9.5	8.8	7.6	7.8	7.5	6.9
Chemistry	6.6	6.7	6.3	6.1	5.9	5.7	6.0	6.2	5.6	5.8	5.8
Physics	6.4	6.1	6.1	5.8	5.6	5.6	5.6	5.3	5.0	4.9	5.0
Earth and space sciences	8.5	8.7	8.7	8.7	8.3	7.9	7.3	7.3	7.6	7.4	7.2
Engineering and technology	8.5	8.3	8.0	7.7	7.8	7.5	7.5	7.5	7.0	6.8	6.7
Mathematics	6.1	6.5	6.7	6.4	6.9	7.5	8.6	5.8	5.7	5.6	6.3
Germany[1]											
All fields	7.3	7.2	7.0	6.9	7.0	6.7	6.9	6.6	6.8	6.8	6.8
Clinical medicine	7.0	6.9	6.8	6.4	6.5	6.1	6.2	6.1	6.4	6.2	6.1
Biomedical research	7.0	7.3	7.2	6.8	6.1	6.1	6.4	6.2	6.3	6.3	6.3
Biology	6.1	5.8	5.2	5.6	5.4	5.3	5.5	5.3	5.3	5.3	5.4
Chemistry	8.5	8.1	8.2	7.9	9.3	8.5	8.8	8.8	8.7	8.3	8.8
Physics	7.6	8.0	8.1	8.3	8.0	7.8	8.1	7.7	7.9	8.1	8.2
Earth and space sciences	4.9	4.9	4.9	4.4	5.1	4.2	4.6	4.2	4.5	4.8	4.7
Engineering and technology	7.6	7.5	6.8	7.5	7.7	7.9	7.6	7.0	7.0	7.1	7.4
Mathematics	11.0	7.7	7.3	7.9	7.9	8.6	6.6	6.4	6.6	6.9	6.9

Field	Article publication year										
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Percent										
France											
All fields	5.0	4.9	4.8	4.8	4.7	4.9	4.8	4.9	4.9	4.8	4.8
Clinical medicine	5.2	5.0	4.7	4.8	4.3	4.6	4.5	4.6	4.5	4.7	4.5
Biomedical research	5.2	5.0	4.9	5.0	5.0	5.0	5.0	5.0	5.0	4.9	5.1
Biology	3.5	3.3	3.4	3.3	3.3	3.1	3.2	3.4	3.4	3.5	3.3
Chemistry	5.9	5.6	5.2	5.3	5.9	5.6	5.9	5.8	5.8	5.5	5.8
Physics	5.9	5.9	6.3	6.5	6.0	6.5	6.0	5.9	5.8	5.6	5.3
Earth and space sciences	4.6	4.5	4.5	4.3	3.8	4.3	4.8	4.6	4.5	4.9	4.5
Engineering and technology	3.3	3.6	3.0	3.1	3.0	3.6	3.4	3.5	3.8	4.1	3.8
Mathematics	5.6	5.9	6.2	6.7	6.9	4.7	5.0	6.6	7.5	4.8	4.6
Italy											
All fields	2.1	2.2	2.4	2.4	2.4	2.3	2.4	2.6	2.7	2.7	2.8
Clinical medicine	2.3	2.4	2.6	2.6	2.9	2.9	2.9	3.1	3.1	3.2	3.4
Biomedical research	2.0	2.0	2.3	2.3	2.1	2.0	1.9	2.1	2.2	2.3	2.3
Biology	1.2	1.4	1.1	1.2	1.0	1.0	1.2	1.2	1.2	1.4	1.4
Chemistry	2.7	2.8	3.1	3.3	2.7	2.7	2.7	3.0	2.9	3.0	2.9
Physics	2.5	2.8	3.0	2.9	2.8	2.5	2.8	2.8	3.0	2.9	3.0
Earth and space sciences	2.1	2.0	2.0	1.9	1.8	1.9	1.8	2.2	2.4	2.4	2.7
Engineering and technology	1.4	1.5	1.4	1.6	1.7	1.4	1.5	1.8	2.1	2.0	2.1
Mathematics	1.3	1.7	1.7	2.3	2.3	2.7	3.3	2.7	3.2	3.4	3.2
Rest of Western Europe											
All fields	9.4	9.7	9.8	9.9	10.1	10.2	10.4	10.2	10.5	10.8	10.7
Clinical medicine	12.6	13.0	13.2	13.0	13.1	13.1	13.1	12.9	13.1	13.5	13.3
Biomedical research	12.3	13.0	13.0	13.0	13.0	13.2	13.2	12.9	13.4	13.5	13.3
Biology	9.8	9.8	9.9	10.2	9.9	10.1	10.2	10.2	10.3	10.6	11.0
Chemistry	7.1	7.1	7.6	7.3	8.0	8.4	8.4	8.9	9.4	10.0	9.8
Physics	8.0	8.1	8.3	8.5	9.4	9.5	9.5	9.3	9.3	9.9	9.9
Earth and space sciences	8.3	8.4	8.6	8.8	8.3	8.2	8.9	8.1	8.3	8.6	8.9
Engineering and technology	6.2	6.0	6.5	6.9	8.2	7.7	8.1	8.5	8.8	9.6	9.5
Mathematics	6.5	6.2	6.5	6.6	6.2	6.3	6.9	6.9	7.1	7.5	7.8

(continued)

Appendix table 5–23.
Country shares of world scientific and technical literature, by field: 1981–91
(page 2 of 3)

Field	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Percent										
Japan											
All fields	6.8	7.0	7.1	7.3	7.6	7.7	7.6	8.2	8.1	8.3	8.5
Clinical medicine	5.1	5.3	5.6	5.9	6.3	6.4	6.7	6.8	7.3	7.3	7.9
Biomedical research	6.2	6.4	6.6	6.7	6.7	7.1	7.1	7.4	7.5	7.8	7.9
Biology	6.1	6.3	6.3	6.7	7.0	6.5	6.9	7.1	6.9	6.9	7.5
Chemistry	10.9	10.7	10.3	10.6	10.7	10.7	10.8	10.7	10.5	11.5	10.9
Physics	8.2	8.3	8.0	8.1	8.8	8.6	8.5	10.6	10.0	10.2	10.0
Earth and space sciences	2.3	2.2	2.3	2.5	3.3	3.7	3.5	3.4	3.9	3.8	3.7
Engineering and technology	9.2	9.6	10.3	10.9	11.5	12.7	10.1	11.1	10.1	10.0	10.1
Mathematics	4.3	5.0	5.3	5.3	5.2	3.4	3.6	4.4	4.3	3.5	4.6
Canada											
All fields	3.9	3.9	4.0	4.2	4.3	4.3	4.4	4.4	4.3	4.2	4.2
Clinical medicine	3.4	3.4	3.6	3.8	3.8	4.0	4.1	4.1	4.0	3.8	4.0
Biomedical research	4.1	4.0	4.4	4.4	4.1	4.0	4.3	4.3	4.2	4.4	4.2
Biology	6.3	6.8	7.0	7.4	8.3	8.4	8.6	9.0	8.2	8.2	8.0
Chemistry	3.1	3.1	2.9	3.0	3.1	3.1	3.2	3.0	2.9	3.0	2.8
Physics	2.9	2.9	2.9	3.1	3.2	3.1	2.8	2.8	2.7	2.7	3.0
Earth and space sciences	5.2	5.7	5.5	6.3	5.9	6.7	6.8	6.6	7.0	7.2	6.8
Engineering and technology	4.2	4.0	4.2	4.5	4.8	4.9	5.1	5.0	4.8	4.8	4.9
Mathematics	5.1	4.8	5.0	4.6	4.6	4.7	4.5	5.1	5.4	4.8	4.6
Former Soviet Union											
All fields	8.0	8.2	8.3	7.9	7.8	7.6	7.3	7.6	7.4	7.1	6.7
Clinical medicine	3.3	3.3	3.3	3.1	2.9	2.9	2.8	3.1	2.8	2.6	2.8
Biomedical research	5.7	6.3	6.0	6.0	8.7	8.3	8.0	8.3	7.5	7.2	6.9
Biology	2.8	2.8	2.8	2.9	2.7	2.4	2.3	2.6	2.3	2.3	2.2
Chemistry	16.7	16.7	18.6	17.3	15.3	15.1	13.9	15.0	14.5	14.1	12.4
Physics	16.8	16.8	16.3	16.5	15.6	14.7	14.3	14.4	15.2	14.6	13.0
Earth and space sciences	10.0	10.6	10.6	9.5	7.1	7.0	7.1	6.4	6.9	6.4	5.5
Engineering and technology	7.6	7.3	7.2	7.0	5.9	5.6	5.6	5.1	4.9	4.6	5.6
Mathematics	7.6	6.7	6.3	5.9	2.9	4.6	4.8	3.6	3.2	5.0	4.4

Field	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Percent										
Other Eastern/Central Europe											
All fields	3.0	2.6	2.8	2.8	2.7	2.5	2.4	2.3	2.4	2.2	2.1
Clinical medicine	1.8	1.5	1.5	1.5	1.3	1.3	1.2	1.1	1.1	1.0	0.9
Biomedical research	3.1	2.6	2.6	2.5	2.7	2.6	2.6	2.3	2.3	2.2	2.0
Biology	2.7	2.3	2.6	2.6	2.2	1.4	1.2	1.2	1.4	1.3	1.2
Chemistry	6.0	5.3	6.1	6.0	5.8	5.5	5.3	4.9	5.4	4.6	4.8
Physics	3.5	3.2	3.5	3.3	3.2	3.3	3.2	3.2	3.2	3.2	3.0
Earth and space sciences	1.5	1.4	1.5	1.4	1.3	1.5	1.3	1.2	1.1	1.3	1.4
Engineering and technology	2.2	2.2	2.1	2.4	2.0	1.8	2.2	2.2	2.1	1.9	1.9
Mathematics	3.1	3.3	3.3	3.8	4.6	3.6	3.3	4.1	4.0	3.3	3.2
Israel											
All fields	1.0	1.1	1.1	1.0	1.1	1.0	1.1	1.0	1.0	1.0	0.9
Clinical medicine	1.1	1.2	1.2	1.2	1.3	1.2	1.3	1.2	1.2	1.1	1.1
Biomedical research	1.0	1.1	1.1	1.0	1.0	1.0	0.9	0.9	0.9	0.9	0.8
Biology	1.1	1.1	1.1	1.1	1.2	1.1	1.2	1.1	1.2	1.1	1.1
Chemistry	0.6	0.6	0.6	0.6	0.7	0.6	0.6	0.5	0.6	0.5	0.5
Physics	1.1	1.2	1.1	1.0	1.0	1.0	1.0	1.1	1.0	1.0	0.9
Earth and space sciences	0.8	0.8	0.8	0.7	0.8	0.7	0.9	0.9	0.8	0.7	0.8
Engineering and technology	1.0	1.0	0.9	1.0	1.2	1.1	1.0	1.0	1.0	0.9	0.8
Mathematics	1.5	1.8	2.0	1.4	1.6	1.9	1.8	1.7	1.5	2.0	1.4
Near East and Africa											
All fields	1.6	1.4	1.4	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6
Clinical medicine	1.6	1.7	1.7	1.7	1.6	1.8	1.7	1.7	1.7	1.5	1.5
Biomedical research	0.9	0.9	0.9	0.9	1.0	1.0	1.2	1.1	1.1	0.9	0.9
Biology	2.9	2.6	2.8	2.7	2.9	3.1	3.2	3.2	3.2	3.1	3.1
Chemistry	1.6	1.6	1.3	1.5	1.6	1.9	1.9	1.9	2.1	2.0	2.2
Physics	0.7	0.7	0.7	0.7	0.7	0.8	0.7	0.6	0.6	0.7	0.8
Earth and space sciences	1.4	1.1	1.3	1.3	1.8	1.8	1.9	2.1	2.0	1.8	2.0
Engineering and technology	1.5	1.4	1.5	1.4	1.8	1.7	2.0	2.0	2.1	1.8	1.6
Mathematics	1.3	1.5	1.1	1.4	1.6	1.3	1.4	1.6	1.4	1.2	0.8

(continued)

Appendix table 5–23.

Country shares of world scientific and technical literature, by field: 1981–91

(page 3 of 3)

Field	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Percent										
Australia and New Zealand											
All fields	2.7	2.6	2.6	2.6	2.5	2.5	2.5	2.6	2.5	2.5	2.5
Clinical medicine	2.6	2.6	2.7	2.6	2.7	2.7	2.7	2.7	2.8	2.6	2.7
Biomedical research	2.2	2.2	2.1	2.2	2.2	2.2	2.1	2.2	2.2	2.1	2.2
Biology	6.0	5.4	5.8	5.6	6.1	6.2	6.0	6.3	6.3	6.5	6.1
Chemistry	2.0	1.9	1.7	1.9	1.6	1.6	1.7	1.6	1.6	1.6	1.5
Physics	1.5	1.6	1.4	1.3	1.3	1.3	1.3	1.3	1.1	1.1	1.1
Earth and space sciences	4.0	3.9	3.9	4.3	3.8	4.1	3.7	3.5	4.0	3.8	3.6
Engineering and technology	1.8	1.9	2.0	2.0	1.9	1.9	1.9	1.8	1.7	1.7	1.6
Mathematics	2.2	2.4	2.0	2.0	2.3	2.2	2.2	2.1	2.2	1.9	1.8
India											
All fields	3.2	3.0	2.9	2.8	2.5	2.3	2.2	2.1	2.1	2.0	2.0
Clinical medicine	1.3	1.2	1.2	1.1	0.9	0.8	0.9	0.9	0.8	0.9	0.9
Biomedical research	2.9	2.2	2.3	2.3	2.5	2.5	2.1	1.7	1.9	1.4	1.4
Biology	4.9	4.7	4.3	4.1	2.5	2.3	2.5	2.5	2.3	2.0	2.1
Chemistry	5.9	5.7	5.3	5.6	4.8	4.8	4.1	4.0	4.5	4.1	4.1
Physics	3.8	3.7	3.8	3.6	2.9	2.8	2.6	2.5	2.4	2.4	2.5
Earth and space sciences	2.8	2.9	3.0	3.2	2.8	3.0	2.3	2.5	2.1	2.2	2.4
Engineering and technology	3.1	3.3	3.0	2.8	3.1	3.1	3.3	3.2	2.9	2.6	3.0
Mathematics	3.3	3.6	3.4	3.3	3.1	1.6	1.2	1.5	1.4	1.3	1.2
Central and South America											
All fields	1.2	1.3	1.3	1.2	1.2	1.2	1.3	1.2	1.2	1.5	1.4
Clinical medicine	1.2	1.2	1.2	1.0	1.0	1.1	1.0	0.9	1.2	1.3	1.1
Biomedical research	1.4	1.3	1.4	1.4	1.4	1.3	1.4	1.4	1.4	1.4	1.5
Biology	1.6	1.7	1.6	1.8	1.6	1.7	1.8	1.8	1.8	2.1	2.3
Chemistry	0.9	1.1	1.0	0.9	1.1	1.2	1.2	1.1	1.2	1.1	1.2
Physics	1.2	1.4	1.3	1.6	1.4	1.4	1.5	1.4	1.5	1.6	1.7
Earth and space sciences	1.3	1.2	1.3	1.3	1.1	1.4	1.6	1.4	1.5	1.6	1.7
Engineering and technology	0.5	0.5	0.8	0.7	0.7	0.6	0.7	0.9	0.8	0.8	0.7
Mathematics	0.8	1.0	0.9	1.3	1.2	1.5	1.6	1.3	1.4	1.6	1.6

Field	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Percent										
China											
All fields	0.3	0.4	0.5	0.4	0.5	0.6	0.7	0.9	0.9	1.1	1.1
Clinical medicine	0.1	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.5	0.4
Biomedical research	0.1	0.2	0.2	0.1	0.3	0.4	0.4	0.4	0.4	0.5	0.5
Biology	0.5	0.7	0.7	0.6	0.4	0.3	0.4	0.3	0.4	0.5	0.5
Chemistry	0.2	0.3	0.3	0.2	0.3	0.5	0.8	0.9	1.0	1.4	1.5
Physics	0.5	0.8	0.7	0.8	1.1	1.3	1.7	2.4	2.4	2.7	2.5
Earth and space sciences	1.4	1.5	1.3	1.7	1.5	1.0	0.9	1.1	0.6	0.7	1.3
Engineering and technology	0.4	0.4	0.7	0.6	0.8	1.1	1.4	1.6	2.2	2.2	2.2
Mathematics	0.3	1.0	1.2	1.2	0.7	0.7	1.0	1.2	1.3	2.0	2.1
East Asian Newly Industrialized Countries											
All fields	0.2	0.2	0.2	0.3	0.4	0.4	0.6	0.7	0.8	1.0	1.1
Clinical medicine	0.1	0.1	0.1	0.2	0.2	0.2	0.5	0.6	0.7	0.7	0.7
Biomedical research	0.1	0.1	0.1	0.1	0.2	0.2	0.4	0.4	0.5	0.5	0.6
Biology	0.2	0.2	0.3	0.2	0.3	0.3	0.5	0.6	0.7	0.6	0.7
Chemistry	0.2	0.3	0.4	0.4	0.5	0.7	0.9	0.9	1.2	1.4	1.7
Physics	0.2	0.3	0.3	0.3	0.4	0.5	0.6	0.7	0.9	1.0	1.2
Earth and space sciences	0.1	0.1	0.1	0.1	0.1	0.2	0.4	0.2	0.3	0.4	0.4
Engineering and technology	0.4	0.4	0.6	0.7	1.0	1.3	1.8	2.2	2.6	3.1	3.4
Mathematics	0.4	0.6	0.4	0.4	0.7	0.5	0.7	1.0	1.2	1.0	1.1
Other Asian/Pacific											
All fields	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3
Clinical medicine	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.3	0.3
Biomedical research	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Biology	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.8
Chemistry	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Physics	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2
Earth and space sciences	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2
Engineering and technology	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Mathematics	0.2	0.1	0.2	0.2	0.3	0.2	0.1	0.4	0.3	0.4	0.3

NOTE: German data are for East and West Germany combined.

SOURCE: CHI Research, Inc., *Science & Engineering Indicators* Literature Database, special tabulations, 1993.

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Appendix table 5-24.
Internationally coauthored scientific and technical articles, by field: 1976–91

Field	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total number of articles																
All fields	266,453	262,993	270,124	268,007	269,569	368,956	371,767	373,548	369,930	390,069	387,190	378,316	393,025	403,847	405,614	405,554
Clinical medicine	75,929	77,487	81,211	78,828	80,546	116,385	118,188	119,326	119,095	125,718	126,586	124,977	125,787	130,106	129,843	130,107
Biomedical research	41,832	41,314	42,903	43,591	44,272	55,306	57,206	57,285	56,219	64,717	64,552	64,217	65,257	68,616	68,769	69,205
Biology	23,907	23,761	23,266	24,830	22,836	39,235	39,024	37,786	38,092	34,932	34,164	32,775	33,426	34,199	35,626	34,233
Chemistry	43,400	40,905	43,813	43,249	44,446	54,433	55,382	54,188	54,119	55,268	55,558	53,236	55,679	56,126	57,723	56,731
Physics	36,818	35,897	35,802	36,688	37,943	45,563	47,231	46,905	46,452	54,044	54,056	53,377	60,757	61,450	60,799	60,758
Earth and space sciences	11,326	11,053	11,218	11,586	11,394	16,991	16,661	16,508	16,335	17,834	18,351	18,285	17,490	18,714	18,902	19,509
Engineering and technology	25,114	25,007	24,587	22,181	21,459	30,709	28,601	32,072	30,309	28,005	26,201	24,344	25,461	25,442	26,670	27,618
Mathematics	8,127	7,569	7,325	7,053	6,673	10,334	9,473	9,478	9,309	9,551	7,722	7,105	9,168	9,194	7,282	7,393
Number of internationally coauthored articles																
All fields	10,561	11,338	12,317	13,227	14,057	20,414	21,745	23,275	24,799	27,522	28,936	30,866	33,635	36,648	39,783	44,680
Clinical medicine	2,314	2,440	2,709	2,837	3,032	4,725	5,084	5,554	5,751	6,735	7,179	7,826	8,450	9,216	9,939	10,699
Biomedical research	1,862	2,032	2,147	2,393	2,533	3,415	3,765	3,965	4,181	4,836	5,356	5,767	6,126	6,756	7,542	8,223
Biology	853	915	1,011	1,121	1,051	1,898	1,804	2,034	2,308	2,211	2,233	2,380	2,673	2,910	3,263	3,423
Chemistry	1,384	1,546	1,598	1,761	1,932	2,565	2,802	2,857	3,073	3,217	3,402	3,523	3,792	4,154	4,473	5,181
Physics	2,142	2,321	2,548	2,757	2,960	3,881	4,217	4,334	4,646	5,522	5,683	6,123	6,848	7,417	7,969	9,758
Earth and space sciences	830	849	963	1,021	1,108	1,586	1,709	1,827	2,065	2,154	2,278	2,468	2,445	2,805	3,176	3,536
Engineering and technology	627	721	806	803	842	1,428	1,416	1,686	1,680	1,653	1,770	1,725	1,913	2,016	2,204	2,595
Mathematics	549	515	536	534	600	914	948	1,019	1,096	1,194	1,035	1,054	1,388	1,374	1,217	1,265
Internationally coauthored articles as a percentage of all articles																
All fields	4.0	4.3	4.6	4.9	5.2	5.5	5.8	6.2	6.7	7.1	7.5	8.2	8.6	9.1	9.8	11.0
Clinical medicine	3.0	3.1	3.3	3.6	3.8	4.1	4.3	4.7	4.8	5.4	5.7	6.3	6.7	7.1	7.7	8.2
Biomedical research	4.5	4.9	5.0	5.5	5.7	6.2	6.6	6.9	7.4	7.5	8.3	9.0	9.4	9.8	11.0	11.9
Biology	3.6	3.9	4.3	4.5	4.6	4.8	4.6	5.4	6.1	6.3	6.5	7.3	8.0	8.5	9.2	10.0
Chemistry	3.2	3.8	3.6	4.1	4.3	4.7	5.1	5.3	5.7	5.8	6.1	6.6	6.8	7.4	7.7	9.1
Physics	5.8	6.5	7.1	7.5	7.8	8.5	8.9	9.2	10.0	10.2	10.5	11.5	11.3	12.1	13.1	16.1
Earth and space sciences	7.3	7.7	8.6	8.8	9.7	9.3	10.3	11.1	12.6	12.1	12.4	13.5	14.0	15.0	16.8	18.1
Engineering and technology	2.5	2.9	3.3	3.6	3.9	4.7	5.0	5.3	5.5	5.9	6.8	7.1	7.5	7.9	8.3	9.4
Mathematics	6.8	6.8	7.3	7.6	9.0	8.8	10.0	10.8	11.8	12.5	13.4	14.8	15.1	14.9	16.7	17.1

SOURCE: CHI Research, Inc., *Science & Engineering Indicators* Literature Database, special tabulations, 1993.

See figure 5-15.

Appendix table 5–25.

U.S. scientific and technical articles, by field and sector: 1981–91

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	Sector													
Field	All	Academic	Industry	Federal	Nonprofit	FFRDC	Other	All	Academic	Industry	Federal	Nonprofit	FFRDC	Other
	Number							Percent						
1981														
Total, all fields	132,280	90,411	11,140	13,098	9,959	4,791	2,882	100.0	68.3	8.4	9.9	7.5	3.6	2.2
Clinical medicine	48,073	32,841	1,563	4,995	6,746	256	1,673	100.0	68.3	3.3	10.4	14.0	0.5	3.5
Biomedical research	21,847	16,904	563	2,100	1,578	377	326	100.0	77.4	2.6	9.6	7.2	1.7	1.5
Biology	14,740	11,053	331	2,221	553	130	451	100.0	75.0	2.2	15.1	3.8	0.9	3.1
Chemistry	10,880	7,647	1,798	687	243	437	68	100.0	70.3	16.5	6.3	2.2	4.0	0.6
Physics	13,053	8,123	2,135	835	180	1,753	27	100.0	62.2	16.4	6.4	1.4	13.4	0.2
Earth and space sciences	7,257	4,710	408	1,164	315	562	98	100.0	64.9	5.6	16.0	4.3	7.7	1.3
Engineering & technology	12,486	5,555	4,191	1,009	283	1,220	229	100.0	44.5	33.6	8.1	2.3	9.8	1.8
Mathematics	3,943	3,579	151	87	61	56	11	100.0	90.8	3.8	2.2	1.5	1.4	0.3
1983														
Total, all fields	132,416	90,555	11,759	12,879	9,932	4,627	2,663	100.0	68.4	8.9	9.7	7.5	3.5	2.0
Clinical medicine	48,056	32,872	1,732	4,916	6,746	207	1,583	100.0	68.4	3.6	10.2	14.0	0.4	3.3
Biomedical research	22,496	17,359	687	2,128	1,638	342	343	100.0	77.2	3.1	9.5	7.3	1.5	1.5
Biology	14,216	10,804	341	2,136	471	113	350	100.0	76.0	2.4	15.0	3.3	0.8	2.5
Chemistry	11,010	7,710	1,880	716	214	420	71	100.0	70.0	17.1	6.5	1.9	3.8	0.6
Physics	13,021	8,197	2,086	760	200	1,727	51	100.0	63.0	16.0	5.8	1.5	13.3	0.4
Earth and space sciences	6,862	4,371	448	1,091	330	518	104	100.0	63.7	6.5	15.9	4.8	7.5	1.5
Engineering & technology	13,105	5,936	4,419	1,070	270	1,252	157	100.0	45.3	33.7	8.2	2.1	9.6	1.2
Mathematics	3,649	3,307	165	62	62	47	5	100.0	90.6	4.5	1.7	1.7	1.3	0.1
1985														
Total, all fields	137,771	95,340	11,766	12,899	10,189	4,917	2,660	100.0	69.2	8.5	9.4	7.4	3.6	1.9
Clinical medicine	50,596	35,008	1,834	4,971	6,943	288	1,551	100.0	69.2	3.6	9.8	13.7	0.6	3.1
Biomedical research	24,460	18,825	921	2,253	1,771	332	358	100.0	77.0	3.8	9.2	7.2	1.4	1.5
Biology	13,083	10,077	383	1,792	398	96	337	100.0	77.0	2.9	13.7	3.0	0.7	2.6
Chemistry	11,585	8,137	1,950	794	217	418	69	100.0	70.2	16.8	6.9	1.9	3.6	0.6
Physics	15,903	9,802	2,823	933	234	2,054	57	100.0	61.6	17.7	5.9	1.5	12.9	0.4
Earth and space sciences	7,663	4,795	598	1,197	364	533	177	100.0	62.6	7.8	15.6	4.7	7.0	2.3
Engineering & technology	10,822	5,442	3,081	846	198	1,152	102	100.0	50.3	28.5	7.8	1.8	10.6	0.9
Mathematics	3,659	3,254	176	111	63	44	11	100.0	88.9	4.8	3.0	1.7	1.2	0.3

(continued)

Appendix table 5–25.

U.S. scientific and technical articles, by field and sector: 1981–91

(page 2 of 2)

Field	All	Academic	Industry	Federal	Nonprofit	FFRDC	Other	All	Academic	Industry	Federal	Nonprofit	FFRDC	Other
	Number							Percent						
1987														
Total, all fields	134,498	94,424	11,273	12,255	9,546	4,619	2,383	100.0	70.2	8.4	9.1	7.1	3.4	1.8
Clinical medicine	49,905	34,787	2,075	4,867	6,498	203	1,475	100.0	69.7	4.2	9.8	13.0	0.4	3.0
Biomedical research	24,542	18,571	1,208	2,303	1,778	356	325	100.0	75.7	4.9	9.4	7.2	1.5	1.3
Biology	12,231	9,547	359	1,670	328	72	255	100.0	78.1	2.9	13.7	2.7	0.6	2.1
Chemistry	11,827	8,455	2,010	694	182	439	48	100.0	71.5	17.0	5.9	1.5	3.7	0.4
Physics	16,078	10,209	2,739	853	229	2,006	41	100.0	63.5	17.0	5.3	1.4	12.5	0.3
Earth and space sciences	7,797	4,984	587	1,169	323	568	166	100.0	63.9	7.5	15.0	4.1	7.3	2.1
Engineering & technology	9,225	5,291	2,165	630	151	921	67	100.0	57.4	23.5	6.8	1.6	10.0	0.7
Mathematics	2,893	2,580	130	68	57	53	5	100.0	89.2	4.5	2.4	2.0	1.8	0.2
1989														
Total, all fields	140,832	99,215	11,963	12,372	10,360	4,532	2,390	100.0	70.4	8.5	8.8	7.4	3.2	1.7
Clinical medicine	50,510	34,938	2,380	4,685	6,841	193	1,472	100.0	69.2	4.7	9.3	13.5	0.4	2.9
Biomedical research	26,541	20,157	1,367	2,385	2,015	357	261	100.0	75.9	5.1	9.0	7.6	1.3	1.0
Biology	12,726	9,705	385	1,812	431	85	308	100.0	76.3	3.0	14.2	3.4	0.7	2.4
Chemistry	12,405	9,025	1,960	685	190	489	55	100.0	72.8	15.8	5.5	1.5	3.9	0.4
Physics	17,649	11,392	2,915	949	245	2,107	41	100.0	64.5	16.5	5.4	1.4	11.9	0.2
Earth and space sciences	7,770	4,954	565	1,112	429	534	176	100.0	63.8	7.3	14.3	5.5	6.9	2.3
Engineering & technology	9,568	5,676	2,266	678	169	715	65	100.0	59.3	23.7	7.1	1.8	7.5	0.7
Mathematics	3,664	3,367	126	66	40	52	12	100.0	91.9	3.4	1.8	1.1	1.4	0.3
1991														
Total, all fields	142,333	100,275	12,660	12,265	10,242	4,392	2,499	100.0	70.5	8.9	8.6	7.2	3.1	1.8
Clinical medicine	50,142	34,794	2,545	4,510	6,678	195	1,419	100.0	69.4	5.1	9.0	13.3	0.4	2.8
Biomedical research	26,918	20,444	1,524	2,258	1,982	413	298	100.0	75.9	5.7	8.4	7.4	1.5	1.1
Biology	12,862	9,742	439	1,875	422	59	325	100.0	75.7	3.4	14.6	3.3	0.5	2.5
Chemistry	13,086	9,446	2,122	699	239	485	95	100.0	72.2	16.2	5.3	1.8	3.7	0.7
Physics	18,078	11,866	2,889	1,000	249	2,017	57	100.0	65.6	16.0	5.5	1.4	11.2	0.3
Earth and space sciences	8,138	5,155	605	1,149	471	569	189	100.0	63.3	7.4	14.1	5.8	7.0	2.3
Engineering & technology	9,999	5,978	2,441	715	153	608	103	100.0	59.8	24.4	7.1	1.5	6.1	1.0
Mathematics	3,111	2,849	95	60	50	46	12	100.0	91.6	3.0	1.9	1.6	1.5	0.4

FFRDC = federally funded research and development center

SOURCE: CHI Research, Inc., *Science & Engineering Indicators* Literature Database, special tabulations.

Appendix table 5–26.
U.S. academic-industry coauthored scientific and technical articles as a proportion of all industry articles, by field: 1981–91

Field	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
	Percent										
All fields	22	24	23	25	27	28	30	31	32	33	35
Clinical medicine	30	34	33	35	40	37	42	41	42	44	45
Biomedical research	35	37	35	35	39	38	40	41	39	39	40
Biology	39	46	42	37	44	44	41	47	48	43	45
Chemistry	13	17	15	16	16	18	20	20	22	22	24
Physics	20	21	23	25	23	23	25	26	28	29	31
Earth and space sciences	34	35	33	36	33	36	34	41	38	40	37
Engineering and technology	16	17	16	17	18	20	23	24	23	26	26
Mathematics	43	35	42	42	43	40	42	41	51	52	49

SOURCE: CHI Research, Inc., *Science & Engineering Indicators* Literature Database, special tabulations, 1993.

Appendix table 5–27.
U.S. patents awarded to the 100 academic institutions with the greatest R&D volume: 1969–91
(page 1 of 3)

Institution	Total 1969–91	1969–71	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
All academic patents . . .	11,926	636	238	259	250	321	358	363	369	264	390	437	459	434	551	587	670	818	806	1,218	1,174	1,324
Patents to top 100 R&D performers	8,399	476	181	189	180	242	281	285	289	199	290	335	360	343	416	453	521	682	671	1,022	992	1,112
MA Inst. of Technology . .	1,210	94	28	40	37	44	59	39	53	43	44	66	51	47	47	35	45	63	63	101	110	101
University of California . . .	838	59	16	25	22	17	22	25	23	1	2	38	42	48	46	42	54	67	60	81	64	84
CA Inst. of Technology. . .	464	29	17	14	15	27	18	16	18	12	26	16	19	16	15	16	23	27	18	56	30	36
Stanford University	472	3	3	6	7	16	19	18	10	4	11	10	4	16	36	38	33	48	54	43	36	57
University of Wisconsin . .	383	15	12	13	8	17	20	25	13	7	28	26	17	13	16	17	17	11	20	27	16	45
Iowa State University. . . .	371	42	11	14	20	15	14	15	12	8	12	12	15	10	14	21	9	15	15	28	30	39
University of Minnesota . .	290	15	9	6	4	5	3	5	6	7	6	12	10	5	6	11	16	28	26	40	38	32
Cornell University	283	11	1	2	3	5	10	10	10	7	11	8	6	10	14	20	13	30	16	22	34	40
University of Texas	306	0	0	0	0	0	0	1	2	0	1	6	7	5	8	20	25	21	21	51	54	84
Johns Hopkins Univ.[1]. . . .	239	9	7	5	4	10	3	9	10	4	6	9	8	6	10	15	18	18	21	27	15	25
Purdue University	215	16	10	4	1	13	15	12	6	4	13	15	11	11	14	18	9	4	2	11	15	11
University of Utah	203	15	8	3	2	5	7	6	12	17	12	7	14	15	9	11	7	12	9	13	14	5
University of Illinois	198	17	7	8	9	9	14	11	11	6	10	8	7	8	8	10	12	4	9	15	7	8
Ohio State University. . . .	191	38	12	8	3	4	7	9	8	0	3	4	5	8	3	10	5	12	14	13	10	15
University of Florida.	192	0	0	1	1	2	2	0	1	3	7	4	0	6	10	7	10	13	21	33	33	38
State Univ. of NY.	140	0	0	0	0	0	0	0	0	0	1	2	8	2	11	5	11	18	10	25	20	27
GA Inst. of Technology . .	125	6	0	3	5	1	1	2	2	5	3	7	8	3	6	11	9	9	7	8	18	11
University of Michigan . . .	130	0	0	0	4	0	2	8	2	4	4	1	2	2	1	1	10	6	14	23	25	21
Harvard University.	113	0	0	0	0	0	0	1	2	0	4	3	11	10	7	1	2	9	17	15	23	8
University of Rochester . .	112	0	0	0	0	0	4	2	4	0	6	7	8	9	6	2	8	9	11	11	13	12
Univ. of Southern CA. . . .	103	0	0	2	3	4	5	6	15	6	7	2	5	1	7	5	5	4	7	8	6	5
Northwestern University. .	96	12	0	2	1	0	0	2	7	5	7	1	7	3	2	2	8	10	10	7	5	5
University of Kentucky . . .	93	8	2	3	6	0	0	1	3	2	5	4	6	6	7	5	7	4	7	6	4	7
University of Iowa	84	2	0	0	0	0	3	3	2	5	4	4	5	3	4	1	8	8	6	8	12	6
University of Virginia	89	0	0	1	3	0	3	7	8	6	1	3	8	4	2	1	4	3	4	8	12	11
University of Pittsburgh . .	91	0	0	0	0	0	0	0	0	2	6	3	2	5	8	3	8	10	6	11	11	16
Indiana University	75	24	5	2	0	1	4	4	7	2	2	1	0	3	2	4	0	3	1	6	1	3
Columbia University.	80	0	0	0	0	0	0	0	0	0	0	0	0	2	3	4	7	6	15	19	16	8
University of Missouri. . . .	79	0	0	0	2	3	5	0	6	4	1	2	9	5	4	0	3	8	9	5	6	7
University of PA	89	4	1	2	2	1	2	5	5	3	1	1	1	2	4	5	1	2	1	9	19	18

(continued)

Appendix table 5–27.

U.S. patents awarded to the 100 academic institutions with the greatest R&D volume: 1969–91

(page 2 of 3)

Institution	Total 1969–91	1969–71	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
New York University	78	4	2	3	0	2	0	0	0	0	3	1	7	3	4	5	3	5	4	10	14	8
University of Tennessee. .	78	8	1	0	1	0	0	0	0	0	0	1	1	0	1	5	8	8	8	12	14	10
Duke University.	68	2	1	1	1	1	0	0	0	0	2	1	3	3	6	4	6	4	9	11	7	6
Boston University	66	0	0	0	0	0	0	2	1	0	3	2	1	2	2	3	6	9	9	9	11	6
Kansas State University. .	65	2	4	3	3	5	3	2	1	3	3	2	2	4	3	2	4	4	3	4	1	7
Michigan State Univ.	67	0	2	1	0	0	4	0	2	1	2	1	1	3	3	3	10	6	8	2	7	11
Texas A & M University . .	67	0	0	0	0	0	0	0	0	1	0	3	3	2	3	8	3	6	9	8	9	12
Rockefeller University . . .	69	0	0	0	0	0	0	1	0	1	0	3	3	1	3	5	4	9	11	6	8	14
Baylor University	58	0	0	0	0	1	3	4	1	1	1	3	3	2	2	3	2	7	3	8	8	6
Yale University	56	0	0	0	0	0	0	1	0	0	0	0	0	2	2	5	3	12	6	11	10	4
Oregon State Univ.	54	0	0	0	0	0	3	1	1	2	0	4	1	3	4	4	4	6	3	11	3	4
NC State Univ.	61	0	0	0	0	0	0	0	0	1	0	4	1	0	2	3	4	6	5	10	14	11
Washington University . . .	71	2	0	0	1	2	1	1	0	0	3	1	0	1	1	3	1	7	6	12	7	22
University of Alabama . . .	51	1	0	1	0	0	1	4	4	2	3	2	3	1	1	5	3	5	3	3	6	3
University of Miami	49	0	0	0	0	3	1	0	1	0	2	2	2	0	4	4	3	15	5	5	1	1
Wayne State Univ..	55	0	0	0	0	0	0	0	0	0	0	0	2	1	0	1	5	6	7	16	9	8
University of WA	49	0	0	1	0	2	2	1	2	2	0	0	7	2	3	1	2	1	5	3	7	8
Oklahoma State Univ. . . .	41	10	3	3	1	2	2	2	0	1	1	0	1	0	1	2	2	0	2	3	4	1
Case Western Reserve U.	39	6	2	2	3	0	4	3	0	1	1	1	0	0	1	1	6	3	1	1	2	1
City University of NY	42	3	1	2	1	1	0	2	1	0	1	5	4	3	2	1	2	1	3	2	2	5
University of Georgia	45	0	0	0	0	0	0	1	0	0	0	0	0	7	7	5	6	3	0	3	5	8
University of Arizona	45	0	0	0	0	0	0	0	2	1	2	1	1	2	2	2	2	2	0	8	10	10
University of Cincinnati . .	44	0	0	0	1	0	1	0	0	0	0	0	0	0	2	2	1	8	3	8	9	9
University of Nebraska. . .	39	0	1	0	2	5	0	1	1	0	1	5	4	0	5	1	1	1	4	0	3	4
Louisiana State Univ.	39	1	0	1	0	0	0	3	2	0	1	2	0	1	1	1	1	3	4	9	4	5
Yeshiva University.	34	2	1	1	0	3	2	0	0	1	2	0	3	0	1	4	1	6	1	5	1	0
Vanderbilt University	38	0	0	0	0	1	1	0	2	0	1	1	2	1	0	0	5	4	4	4	5	7
Clemson University	33	0	2	0	0	0	0	1	0	4	1	0	0	0	2	2	1	3	3	6	6	2
Georgetown University. . .	34	1	2	0	0	0	0	2	0	0	0	2	1	4	5	1	0	4	3	1	5	3
Carnegie-Mellon Univ. . . .	36	1	0	0	1	1	2	1	4	1	0	0	0	0	3	3	3	1	2	5	3	5

(continued)

Appendix table 5–27.
U.S. patents awarded to the 100 academic institutions with the greatest R&D volume: 1969–91
(page 3 of 3)

Institution	Total 1969–91	1969–71	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
University of Chicago	29	0	0	0	0	2	0	3	1	2	1	0	2	0	2	0	0	1	6	7	2	0
Washington State Univ.	31	1	0	1	0	0	0	0	1	2	2	1	3	2	0	2	2	2	1	5	3	3
University of NM	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	1	3	9	9	10
Univ. of Med. & Den. of NJ	29	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	4	7	2	4	7	2
University of NC	29	1	1	0	0	1	0	0	0	0	1	0	0	1	0	0	3	2	2	6	8	3
University of Oklahoma	29	1	0	0	1	0	0	0	0	0	0	1	1	1	1	3	2	2	6	2	4	4
University of Kansas	28	3	1	2	0	2	2	0	0	0	2	1	0	2	2	1	0	2	0	1	3	4
University of Hawaii	24	0	0	0	0	1	0	1	1	1	2	0	1	1	0	2	0	1	3	2	6	2
Princeton University	34	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	2	1	12	4	13
University of Connecticut	23	1	1	0	0	0	0	0	1	0	1	1	0	0	0	1	1	2	1	2	8	3
Rutgers State Univ. of NJ.	34	0	0	0	0	1	2	1	0	0	0	0	0	0	1	1	0	2	2	7	2	15
Utah State University	22	0	1	0	1	0	0	1	0	2	2	0	0	0	1	3	2	2	1	1	2	3
Colorado State Univ.	22	1	3	0	0	1	0	0	0	0	1	0	0	0	0	1	3	4	2	0	2	4
University of Colorado	24	1	0	0	0	2	1	1	0	0	0	0	0	0	0	0	0	1	0	3	9	6
Tulane University of LA	23	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	1	3	4	4	7
VA Polytechnic Inst.	27	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	7	4	11
University of Maryland	19	1	0	0	0	1	0	0	0	0	0	0	0	1	0	0	3	2	2	1	4	4
Tufts University	19	2	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	2	7	1	5
Brown University	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	2	1	3	3	0
Emory University	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	7	3	10
University of MA	17	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	1	3	3	6
Auburn University	11	1	0	0	0	0	1	1	1	0	1	1	0	0	0	1	1	0	0	0	2	1
Florida State University	10	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	2	2	1	1	1	1
Penn. State Univ.	14	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	1	3	6
New Mexico State Univ.	7	0	0	0	0	1	0	0	0	0	0	0	0	2	0	0	1	2	0	0	0	1
Woods Hole Ocean. Inst.	7	1	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1
Mississippi State Univ.	4	0	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arizona State Univ.	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0
VA Commonwealth Univ.	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1

NOTES: Ranking of academic institutions is based on their 1988 R&D expenditures; not all 100 institutions are listed here because some could not be located in the Technology Assessment and Forecast Program database.

[1] Includes the Applied Physics Laboratory.

SOURCE: Technology Assessment and Forecast Program, U.S. Patent and Trademark Office, *U.S. Universities 1969-1991* (Washington, DC: Oct. 1992).

See figure 5-18.

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Appendix table 5–28.

U.S. patents awarded to U.S. academic institutions by technology class, ordered by volume of 1989–91 patenting activity: 1969–91

(page 1 of 4)

		Cum. percent	Number of patents awarded										
Technology class		1989-91	1969-72	1973-74	1975-76	1977-78	1979-80	1981-82	1983-84	1985-86	1987-88	1989-90	1991
514	Drug, bio-affecting and body treating compositions	9.9	21	14	32	47	52	70	105	119	178	232	136
435	Chemistry: Molecular biology and microbiology	19.0	22	24	29	33	36	74	79	104	175	221	116
424	Drug, bio-affecting and body treating compositions	25.1	27	12	25	33	23	50	67	47	88	139	89
128	Surgery	29.4	26	20	33	26	30	36	45	73	77	109	52
250	Radiant energy	32.5	19	13	21	27	12	17	20	19	38	70	44
324	Electricity, measuring and testing	35.1	20	8	5	8	5	15	16	21	48	67	30
530	Chemistry, lignins or reaction products thereof	37.4	4	4	3	7	5	24	36	33	45	58	26
364	Electrical computers and data processing systems	39.6	7	4	6	8	4	7	12	14	26	61	22
359	Optics, systems (inc. communication) and elements	41.6	14	12	15	10	10	15	7	24	24	44	31
73	Measuring and testing	43.6	45	14	19	27	23	21	27	42	31	55	20
372	Coherent light generators	45.5	8	5	10	6	1	7	11	22	20	43	24
204	Chemistry, electrical and wave energy	47.3	20	13	14	14	12	24	28	16	30	42	25
357	Active solid state devices, e.g., transistors	48.9	2	4	7	4	10	6	8	15	13	38	23
536	Part of the class 532-570 series–organic compounds	50.5	9	4	14	8	7	17	10	15	24	34	27
356	Optics, measuring and testing	52.1	13	5	6	5	14	9	13	19	37	39	19
427	Coating processes	53.7	5	2	2	3	6	7	4	12	16	37	21
210	Liquid purification or separation	55.2	13	11	11	16	8	11	12	19	21	31	25
505	Superconductor technology-apparatus, material, process	56.4	0	0	0	0	0	0	0	0	0	25	22
604	Surgery	57.6	3	2	2	2	9	12	16	20	38	29	16
156	Adhesive bonding & misc. chemical manufacture	58.9	5	0	1	2	3	2	14	8	14	29	16
437	Semiconductor device manufacturing process	60.0	3	1	1	4	10	9	9	14	18	27	16
395	Information processing system organization	61.2	12	3	2	3	6	4	4	5	7	32	11
264	Plastic & nonmet. article shaping or treating: processes	62.2	5	2	5	6	9	6	6	8	10	20	18
436	Chemistry-analytical and immunological testing	63.2	8	5	21	22	21	19	33	25	30	27	11
426	Food or edible material: processes, comp. & products	64.2	12	12	13	14	12	14	15	15	8	22	16
428	Stock material or miscellaneous articles	65.2	6	6	3	7	6	13	15	12	15	24	12
606	Surgery	66.2	8	4	3	2	5	5	12	14	23	22	14
423	Chemistry, inorganic	67.1	21	5	15	21	5	15	6	7	5	24	11
422	Process disinfecting, deodorizing, preserving	68.0	6	2	2	6	5	3	9	7	11	22	12
623	Prothesis (i.e., artificial body members), parts or aids	68.9	14	6	3	4	8	8	2	25	23	19	15
525	Part of the class 520 series–synthetic resins or natural rubbers	69.8	2	2	3	9	9	10	8	15	9	21	12
378	X-ray or gamma ray systems or devices	70.6	7	8	10	14	3	9	4	7	11	20	9
528	Part of the class 520 series–synthetic resins or natural rubbers	71.4	13	0	14	6	2	1	3	3	9	21	8
358	Pictorial communication; television	72.2	7	5	5	6	5	1	5	9	18	18	11

(continued)

Appendix table 5–28.

U.S. patents awarded to U.S. academic institutions by technology class, ordered by volume of 1989–91 patenting activity: 1969–91

(page 2 of 4)

Technology class		Cum. percent 1989-91	Number of patents awarded										
			1969-72	1973-74	1975-76	1977-78	1979-80	1981-82	1983-84	1985-86	1987-88	1989-90	1991
385	Optical waveguides	73.0	1	0	1	1	7	0	9	14	22	22	7
549	Part of the class 532-570 series–organic compounds	73.7	1	3	10	11	11	19	14	13	11	20	9
501	Compositions: ceramic	74.5	0	0	2	1	2	3	1	3	4	17	10
546	Part of the class 532-570 series–organic compounds	75.2	4	5	12	11	5	4	2	5	7	20	6
540	Part of the class 532-570 series–organic compounds	75.9	3	2	6	3	7	7	3	6	12	19	7
548	Part of the class 532-570 series–organic compounds	76.5	1	2	6	6	3	6	2	5	6	15	8
544	Part of the class 532-570 series–organic compounds	77.1	0	2	5	0	2	8	1	4	2	14	9
1	Classification undetermined	77.7	3	1	2	0	0	2	0	0	0	10	13
556	Part of the class 532-570 series–organic compounds	78.3	6	3	1	4	3	4	5	9	12	9	14
252	Compositions	78.9	6	3	6	5	4	6	8	14	10	8	14
71	Chemistry, fertilizers	79.4	2	2	2	1	5	3	2	8	5	16	3
502	Catalyst, solid sorbent, or support therefore	79.9	1	0	3	2	4	7	1	8	9	8	9
219	Electric heating	80.3	3	1	3	5	2	4	3	4	6	7	9
209	Classifying, separating and assorting solids	80.8	9	7	3	5	5	4	6	4	8	9	7
62	Refrigeration	81.2	3	3	4	4	3	2	11	2	8	11	4
365	Static information storage and retrieval	81.6	19	3	3	4	2	4	2	7	5	12	3
119	Animal husbandry	82.0	3	2	1	2	3	1	4	6	6	9	6
165	Heat exchange	82.3	1	1	0	1	2	1	3	2	3	8	5
310	Electrical generator or motor structure	82.7	14	12	7	2	1	3	3	7	6	9	4
382	Image analysis	83.0	0	1	0	1	0	3	1	1	6	9	4
381	Electrical audio signal processing and systems	83.4	6	0	3	4	0	3	4	7	8	9	4
600	Surgery	83.7	1	4	1	3	1	6	4	3	2	9	3
429	Chemistry, electrical current producing apparatus	84.0	4	0	3	4	6	6	8	9	7	9	3
55	Gas separation	84.3	9	2	2	6	2	6	4	6	9	8	4
558	Part of the class 532-570 series–organic compounds	84.7	4	1	3	3	0	2	4	2	5	7	5
526	Part of the class 520 series–synthetic resins or natural rubbers	85.0	0	1	5	2	1	2	0	8	6	6	6
351	Optics, eye examining, vision testing and correcting	85.3	1	2	1	1	1	2	0	2	7	8	4
148	Metal treatment	85.6	2	0	3	7	1	3	2	9	4	8	3
75	Metallurgy	85.9	3	3	4	6	1	5	4	3	7	5	6
585	Chemistry, hydrocarbons	86.2	2	1	2	2	3	3	0	4	5	8	3
123	Internal-combustion engines	86.5	1	2	2	7	2	0	4	3	5	8	3
367	Comm., electrical: acoustic wave systems & devices	86.8	6	2	5	2	2	0	0	2	0	7	3
307	Electrical transmission or interconnection systems	87.0	13	5	9	1	1	4	0	2	4	6	4
341	Coded data generation or conversion	87.3	3	1	2	1	0	0	1	1	4	8	2
342	Communications, directive radio wave systems & devices	87.6	6	6	2	4	1	1	0	2	2	7	3
560	Part of the class 532-570 series–organic compounds	87.8	6	1	11	7	6	10	3	5	4	8	2

(continued)

Appendix table 5–28.

U.S. patents awarded to U.S. academic institutions by technology class, ordered by volume of 1989–91 patenting activity: 1969–91

(page 3 of 4)

Technology class		Cum. percent 1989-91	Number of patents awarded										
			1969-72	1973-74	1975-76	1977-78	1979-80	1981-82	1983-84	1985-86	1987-88	1989-90	1991
430	Radiation imagery chemistry–process, composition or product	88.1	3	0	2	0	2	4	3	7	7	8	1
433	Dentistry	88.3	4	0	3	4	3	2	0	1	9	8	1
361	Electricity, electrical systems and devices	88.6	3	4	2	0	3	0	1	2	0	5	4
562	Part of the class 532-570 series–organic compounds	88.8	4	3	6	3	2	1	2	3	3	5	3
374	Thermal measuring and testing	89.0	1	0	1	3	2	2	6	5	3	7	1
417	Pumps	89.2	1	1	0	1	9	2	2	2	2	3	5
333	Wave transmission lines and networks	89.4	8	2	3	4	9	4	4	3	4	4	4
65	Glass manufacturing	89.6	2	2	2	0	2	1	0	1	4	7	1
340	Communications, electrical	89.9	7	9	5	3	4	2	3	8	8	4	4
414	Material or article handling	90.0	1	3	1	4	1	2	1	2	3	5	2
29	Metal working	90.2	7	0	1	0	0	0	1	3	2	5	2
521	Part of the class 520 series–synthetic resins or natural rubbers	90.4	6	3	3	6	2	1	2	2	0	5	2
206	Special receptacle or package	90.6	0	1	0	0	0	0	0	0	3	5	2
318	Electricity, motive power systems	90.8	7	0	2	3	2	2	3	1	3	1	6
524	Part of the class 520 series–synthetic resins or natural rubbers	91.0	4	1	3	2	1	1	2	2	3	3	4
363	Electric power conversion systems	91.2	1	1	2	3	4	3	4	1	5	6	1
568	Part of the class 532-570 series–organic compounds	91.4	8	5	13	15	1	4	3	10	6	6	1
370	Multiplex communications	91.6	1	1	0	1	1	0	0	4	3	6	1
44	Fuel and igniting devices	91.7	0	0	0	1	1	4	10	5	6	4	2
534	Part of the class 532-570 series–organic compounds	91.9	1	1	5	2	0	1	1	0	4	5	1
52	Static structures, e.g., buildings	92.0	0	3	1	1	1	3	4	1	2	3	3
89	Ordnance	92.2	0	0	0	0	0	0	0	1	0	6	0
74	Machine elements and mechanisms	92.4	4	1	2	4	2	3	1	3	3	3	3
405	Hydraulic and earth engineering	92.5	4	1	1	1	1	1	3	2	3	3	3
375	Pulse or digital communications	92.7	2	3	0	0	2	0	2	2	4	3	3
331	Oscillators	92.8	4	3	2	1	2	1	1	3	1	2	4
205	Electrolysis: processes, compositions used therein & methods	93.0	1	1	1	0	1	3	2	3	3	5	0
272	Amusement and exercising devices	93.1	1	0	0	0	0	1	1	4	5	4	1
47	Plant husbandry	93.2	3	2	0	7	3	2	7	9	1	4	1
134	Cleaning and liquid contact with solids	93.4	0	0	1	1	2	4	3	0	0	4	1
111	Planting	93.5	2	2	0	0	0	3	3	3	2	4	1
294	Handling, hand and hoist-line implements	93.6	0	0	0	1	0	1	0	1	2	2	3

(continued)

Appendix table 5–28.

U.S. patents awarded to U.S. academic institutions by technology class, ordered by volume of 1989–91 patenting activity: 1969–91

(page 4 of 4)

Technology class		Cum. percent 1989-91	Number of patents awarded										
			1969-72	1973-74	1975-76	1977-78	1979-80	1981-82	1983-84	1985-86	1987-88	1989-90	1991
419	Powder metallurgy-processes	93.8	1	0	0	0	0	0	1	2	1	3	2
564	Part of the class 532-570 series–organic compounds	93.9	4	2	4	4	0	0	2	6	4	3	2
420	Alloys or metallic compositions	94.1	3	2	1	0	1	1	0	5	0	4	1
315	Electric lamp and discharge devices, systems	94.2	8	3	3	4	1	2	2	6	3	3	2
343	Communications, radio wave antennas	94.3	15	3	0	4	1	3	1	1	0	4	1
371	Error detection/correction and fault detection/recovery	94.5	1	0	1	1	0	2	1	1	4	3	2
377	Elec. pulse counters, pulse dividers or shift registers	94.6	5	0	0	0	0	0	1	0	1	2	2
222	Dispensing	94.7	2	0	1	1	2	1	1	1	0	2	2
228	Metal fusion bonding	94.8	0	1	1	0	0	0	0	0	1	3	1
248	Supports	94.9	0	2	0	0	0	0	0	0	1	2	2
335	Electricity, magnetically operated switches, magnets	95.0	1	0	3	0	0	0	0	2	0	3	1

SOURCE: Technology Assessment and Forecast Program, U.S. Patent and Trademark Office, *U.S. Universities 1969–1991* (Washington, DC: Oct. 1992).

Science & Engineering Indicators – 1993

Appendix table 6–1.

Gross domestic product for selected countries: 1960–91

	U.S. GDP	United States	Canada	Japan	South Korea	Austria	Belgium	Denmark	France	Germany[1]	Italy	The Netherlands	Norway	Sweden	United Kingdom
	Billions[2]	Relative GDP													
1960	$2,323.76	100.0	7.0	15.2	1.3	1.8	2.5	1.6	13.6	18.6	12.4	3.9	1.1	2.7	19.0
1961	2,385.47	100.0	7.1	16.9	1.3	1.9	2.6	1.6	13.9	18.9	13.1	3.9	1.1	2.8	19.2
1962	2,508.18	100.0	7.2	17.2	1.3	1.8	2.6	1.6	14.2	18.8	13.2	3.9	1.1	2.8	18.4
1963	2,612.05	100.0	7.3	18.3	1.4	1.8	2.6	1.6	14.3	18.6	13.4	3.9	1.1	2.8	18.4
1964	2,759.61	100.0	7.3	19.6	1.4	1.8	2.6	1.6	14.4	18.8	13.0	4.0	1.1	2.9	18.3
1965	2,912.94	100.0	7.4	19.5	1.4	1.8	2.6	1.6	14.3	18.7	12.7	4.0	1.1	2.8	17.8
1966	3,088.18	100.0	7.5	20.4	1.5	1.8	2.5	1.5	14.2	18.2	12.7	3.8	1.1	2.7	17.1
1967	3,168.26	100.0	7.5	22.0	1.5	1.8	2.5	1.5	14.5	17.7	13.3	3.9	1.1	2.7	17.1
1968	3,298.63	100.0	7.6	23.8	1.7	1.8	2.5	1.5	14.5	17.9	13.6	4.0	1.1	2.7	17.2
1969	3,388.25	100.0	7.8	26.0	1.8	1.8	2.6	1.6	15.1	18.7	14.1	4.2	1.1	2.8	16.9
1970	3,386.72	100.0	8.0	28.6	2.0	2.0	2.8	1.6	16.0	19.7	14.8	4.4	1.1	3.0	17.3
1971	3,491.88	100.0	8.2	28.9	2.1	2.0	2.8	1.6	16.3	19.7	14.6	4.5	1.2	2.9	17.3
1972	3,659.11	100.0	8.2	29.9	2.1	2.0	2.8	1.6	16.2	19.6	14.3	4.4	1.2	2.8	16.9
1973	3,849.30	100.0	8.4	30.5	2.3	2.0	2.9	1.6	16.3	19.5	14.6	4.4	1.2	2.8	17.3
1974	3,825.16	100.0	8.9	30.5	2.5	2.1	3.0	1.6	16.9	19.7	15.5	4.6	1.2	2.9	17.3
1975	3,794.07	100.0	9.2	31.7	2.7	2.1	3.0	1.6	17.0	19.6	15.2	4.6	1.3	3.0	17.3
1976	3,981.43	100.0	9.3	31.5	2.9	2.1	3.0	1.6	16.8	19.6	15.4	4.6	1.3	2.9	17.1
1977	4,160.91	100.0	9.2	31.5	3.1	2.1	2.9	1.6	16.6	19.3	15.3	4.5	1.3	2.7	16.5
1978	4,361.46	100.0	9.2	31.5	3.2	2.0	2.8	1.5	16.4	19.0	15.1	4.4	1.3	2.6	16.3
1979	4,471.34	100.0	9.3	32.5	3.4	2.1	2.8	1.5	16.5	19.3	15.6	4.4	1.3	2.7	16.3
1980	4,447.20	100.0	9.5	33.8	3.3	2.1	2.9	1.6	16.9	19.6	16.3	4.5	1.4	2.7	16.1
1981	4,525.87	100.0	9.7	34.4	3.5	2.1	2.9	1.5	16.8	19.3	16.2	4.4	1.4	2.7	15.6
1982	4,428.36	100.0	9.6	36.3	3.8	2.2	3.0	1.6	17.6	19.5	16.5	4.4	1.4	2.8	16.2
1983	4,600.65	100.0	9.5	35.9	4.1	2.1	2.9	1.6	17.0	19.1	16.1	4.3	1.4	2.7	16.2
1984	4,885.52	100.0	9.5	35.2	4.2	2.0	2.8	1.5	16.3	18.5	15.5	4.2	1.4	2.7	15.5
1985	5,040.15	100.0	9.7	35.8	4.4	2.0	2.7	1.6	16.1	18.3	15.5	4.2	1.4	2.6	15.6
1986	5,187.00	100.0	9.7	35.7	4.8	2.0	2.7	1.6	16.0	18.1	15.5	4.1	1.5	2.6	15.8
1987	5,346.46	100.0	9.8	36.1	5.2	2.0	2.6	1.5	15.9	17.8	15.5	4.0	1.4	2.6	16.1
1988	5,556.91	100.0	9.9	36.9	5.6	2.0	2.7	1.5	16.0	17.8	15.5	4.0	1.4	2.6	16.1
1989	5,697.52	100.0	9.9	37.7	5.8	2.0	2.7	1.5	16.2	18.0	15.6	4.1	1.4	2.6	16.1
1990	5,744.04	100.0	9.8	39.3	6.2	2.1	2.8	1.5	16.4	18.7	15.8	4.2	1.4	2.6	16.0
1991	5,677.50	100.0	9.7	41.6	6.8	2.1	2.9	1.5	16.8	19.6	16.2	4.3	1.4	2.5	15.9

NOTES: For relative GDP calculations, United States = 100. Country GDPs were determined using 1985 purchasing power parities.

[1] German data are for the former West Germany only.

[2] U.S. GDP is expressed in constant 1991 dollars.

SOURCE: Bureau of Labor Statistics, unpublished tabulations, February 1993.

See figure 6–1.

Science & Engineering Indicators – 1993

Appendix table 6–2.

Gross domestic product for selected countries, per capita: 1960–91

	U.S. GDP	United States	Canada	Japan	South Korea	Austria	Belgium	Denmark	France	Germany[1]	Italy	The Netherlands	Norway	Sweden	United Kingdom
	Billions[2]	Relative GDP per Capita													
1960	$ 12,855	100.0	71.1	29.4	9.4	46.4	50.1	61.3	53.7	60.7	44.7	61.5	56.0	66.1	65.7
1961	12,983	100.0	71.1	33.0	9.5	48.1	51.9	63.9	55.5	62.0	47.6	61.9	58.3	68.8	66.7
1962	13,442	100.0	72.2	33.8	9.2	47.3	52.5	64.6	56.2	61.9	48.5	61.4	57.4	68.9	64.5
1963	13,798	100.0	72.6	36.1	9.5	47.6	53.0	62.7	56.7	61.3	49.5	61.0	57.6	70.3	65.1
1964	14,378	100.0	72.9	38.8	9.7	48.2	54.0	65.1	57.3	62.1	48.5	62.7	57.6	71.6	65.2
1965	14,988	100.0	73.2	38.7	9.6	47.2	53.1	64.9	57.1	62.1	47.7	62.5	57.7	70.6	63.5
1966	15,708	100.0	73.3	40.5	10.0	47.3	52.0	62.9	56.8	60.4	47.9	60.5	56.7	68.1	61.6
1967	15,941	100.0	73.0	43.7	10.2	47.6	52.9	63.5	58.2	59.2	50.2	62.1	58.9	68.9	62.0
1968	16,432	100.0	73.4	47.3	10.8	48.0	53.3	63.7	58.4	60.4	51.6	63.6	57.9	68.8	62.4
1969	16,713	100.0	75.0	51.5	11.8	50.0	55.8	66.2	61.0	63.2	53.5	66.0	59.0	70.6	61.8
1970	16,513	100.0	76.8	56.5	12.7	54.0	59.9	67.9	64.7	66.6	56.7	69.8	60.5	75.4	63.9
1971	16,813	100.0	78.7	57.3	13.4	55.5	60.8	68.0	65.9	66.7	56.2	70.5	61.7	74.2	64.2
1972	17,431	100.0	79.4	59.0	13.3	56.5	61.5	68.6	65.8	66.6	55.3	69.6	62.1	73.0	63.2
1973	18,162	100.0	81.2	59.6	14.3	56.6	62.3	67.9	66.1	66.7	56.4	69.3	61.6	72.7	65.3
1974	17,883	100.0	84.9	59.3	15.4	59.6	65.7	68.0	68.8	67.9	60.0	72.6	65.4	76.0	65.8
1975	17,567	100.0	87.4	61.3	16.5	60.7	65.7	68.5	69.5	68.4	59.2	73.3	69.0	79.0	66.5
1976	18,256	100.0	88.1	60.8	17.7	61.1	66.6	70.0	69.4	69.6	60.4	73.5	70.6	76.6	66.4
1977	18,888	100.0	87.2	61.0	18.5	61.8	64.6	68.6	68.9	69.4	60.3	72.2	70.4	72.5	64.9
1978	19,591	100.0	87.0	61.1	19.3	59.6	63.9	66.9	68.4	69.0	59.8	70.9	70.7	71.0	64.8
1979	19,863	100.0	88.2	63.1	20.2	61.7	64.4	68.1	69.4	70.8	62.4	71.1	73.0	72.5	65.3
1980	19,530	100.0	89.9	65.9	19.8	64.6	68.2	68.9	71.3	72.5	66.0	72.4	77.1	74.8	65.0
1981	19,679	100.0	91.4	67.3	20.6	63.8	67.0	67.8	71.2	72.0	65.7	70.8	76.9	74.2	63.8
1982	19,071	100.0	90.4	71.1	22.5	66.4	70.2	72.1	74.9	73.6	67.8	71.7	79.3	77.4	66.8
1983	19,634	100.0	89.8	70.5	24.0	66.0	68.5	71.9	72.9	72.9	66.3	70.4	80.4	76.5	67.3
1984	20,667	100.0	90.0	69.4	24.7	63.6	66.4	71.3	69.8	71.4	64.5	68.7	80.5	75.5	65.0
1985	21,132	100.0	91.6	70.8	25.5	63.7	65.4	72.7	69.3	71.4	64.6	68.7	82.6	75.4	65.8
1986	21,550	100.0	92.1	70.8	27.9	63.1	65.2	73.8	69.3	71.5	65.0	68.3	84.1	75.3	67.0
1987	22,015	100.0	92.9	71.8	30.3	62.7	65.1	72.4	69.0	71.0	65.5	67.0	83.6	75.6	68.6
1988	22,673	100.0	93.6	73.7	32.5	63.2	66.3	71.0	69.7	71.0	66.1	66.3	80.3	74.7	69.3
1989	23,030	100.0	93.1	75.7	33.6	64.3	67.5	70.3	71.0	71.6	66.9	67.9	79.2	74.8	69.5
1990	22,980	100.0	91.6	79.6	36.4	66.5	69.5	71.8	72.4	74.0	68.4	70.3	80.5	75.0	69.8
1991	22,466	100.0	90.8	84.7	40.0	69.2	73.7	74.1	74.5	78.2	70.8	72.9	83.5	74.8	69.7

NOTES: For relative GDP calculations, United States = 100. Country GDPs were determined using 1985 purchasing power parities.

[1] German data are for the former West Germany only.

[2] U.S. GDP is expressed in constant 1991 dollars.

SOURCE: Bureau of Labor Statistics, unpublished tabulations, February 1993.

See figure 6–1.

Appendix table 6-3.

Gross domestic product for selected countries, per employed person, 1960–91

	U.S. GDP	United States	Canada	Japan	South Korea	Austria	Belgium	Denmark	France	Germany[1]	Italy	The Netherlands	Norway	Sweden	United Kingdom
	Billions[2]	Relative GDP per employed person													
1960	$34,027	100.0	77.9	23.8	NA	38.7	49.9	52.3	47.0	48.7	41.5	57.9	49.8	51.7	53.9
1961	34,917	100.0	77.1	26.2	NA	39.4	50.7	53.2	48.3	49.0	43.4	57.3	50.6	52.8	53.7
1962	36,073	100.0	77.8	26.8	NA	39.3	50.8	53.5	49.9	49.4	44.8	56.7	50.0	53.0	52.3
1963	37,050	100.0	77.8	28.6	12.5	40.1	51.3	51.7	50.7	49.3	46.8	56.2	50.3	54.1	52.9
1964	38,305	100.0	77.6	30.9	13.1	41.2	52.3	53.4	51.7	50.8	46.7	58.1	51.0	55.1	53.1
1965	39,465	100.0	77.4	31.0	12.7	41.4	52.4	53.3	52.4	51.7	48.0	58.8	51.7	55.1	52.2
1966	40,624	100.0	77.2	32.6	13.5	42.9	52.3	52.1	53.2	51.8	50.3	58.3	51.9	54.6	51.7
1967	40,714	100.0	77.0	35.3	13.8	44.9	54.5	54.1	55.4	53.3	53.1	61.5	54.6	56.9	53.6
1968	41,516	100.0	78.2	38.3	14.4	46.6	55.7	54.6	56.8	55.1	55.5	63.7	54.7	57.2	55.0
1969	41,621	100.0	79.7	42.5	15.9	49.4	58.3	57.4	59.7	58.1	59.2	66.8	56.5	58.9	55.6
1970	41,369	100.0	81.5	46.4	16.8	53.1	62.3	58.5	62.7	60.7	62.4	70.2	57.1	61.8	57.5
1971	42,489	100.0	82.0	46.8	17.3	53.7	62.4	58.1	63.7	60.6	61.8	70.8	57.6	60.9	58.4
1972	43,251	100.0	82.8	49.7	17.0	55.6	64.7	58.9	65.0	61.9	63.4	72.5	58.9	61.0	58.4
1973	44,047	100.0	83.5	51.2	18.0	56.3	66.7	59.2	66.3	63.0	66.2	74.5	59.8	62.0	60.7
1974	42,968	100.0	85.8	52.3	19.2	59.5	70.1	60.3	69.5	65.6	70.2	78.6	63.6	64.3	61.5
1975	43,102	100.0	86.3	53.9	20.1	59.5	69.9	60.5	69.7	66.2	67.7	78.9	64.8	64.5	61.2
1976	43,802	100.0	88.4	54.7	21.0	60.8	73.0	62.2	71.0	69.0	70.5	81.1	65.9	63.9	63.0
1977	44,194	100.0	89.1	56.0	22.3	62.5	73.0	62.2	72.1	70.2	71.6	80.6	66.0	62.2	63.0
1978	44,430	100.0	89.6	57.7	23.3	62.0	74.5	62.1	73.8	71.4	73.7	81.3	67.4	62.7	64.4
1979	44,309	100.0	89.7	60.3	24.8	64.8	75.6	63.7	76.3	73.3	77.5	82.0	69.9	64.4	65.2
1980	43,856	100.0	89.3	62.5	24.5	67.1	79.8	64.4	78.3	73.7	80.4	81.0	72.0	65.4	65.2
1981	44,138	100.0	89.6	63.8	25.4	66.5	80.1	64.3	79.2	73.4	80.2	79.5	71.5	64.9	66.4
1982	43,541	100.0	91.0	66.1	26.9	69.0	83.4	66.8	82.2	74.6	81.6	79.9	72.6	66.7	69.0
1983	44,652	100.0	91.1	65.1	29.1	69.1	82.6	66.6	81.0	75.0	80.1	80.6	74.3	66.0	70.1
1984	45,564	100.0	92.7	66.1	31.3	68.6	82.8	67.0	81.2	75.4	80.2	80.4	76.6	66.7	68.9
1985	46,078	100.0	93.5	68.2	31.9	69.3	82.1	67.4	82.1	75.4	81.0	79.3	77.6	66.8	69.8
1986	46,378	100.0	93.4	69.0	34.4	69.4	82.3	67.6	83.5	75.5	82.2	79.2	78.0	67.4	71.8
1987	46,614	100.0	94.1	70.7	36.4	70.2	83.2	66.9	84.7	75.7	84.5	78.1	77.5	68.4	73.2
1988	47,417	100.0	94.1	72.6	38.7	71.4	84.6	66.9	86.3	76.6	85.2	77.7	76.4	67.8	72.6
1989	47,658	100.0	94.0	74.2	39.3	72.8	86.2	67.3	88.4	77.6	87.7	79.4	78.3	68.1	72.0
1990	47,835	100.0	92.6	76.2	41.5	74.3	87.5	68.8	89.2	78.9	88.1	79.3	79.9	67.7	71.7
1991	47,712	100.0	92.9	78.3	43.8	75.5	89.8	70.4	90.1	80.0	88.4	79.8	82.4	67.9	72.1

NOTES: For relative GDP calculations, United States = 100. Country GDPs were determined using 1985 purchasing power parities.

[1] German data are for the former West Germany only.

[2] U.S. GDP is expressed in constant 1991 dollars.

SOURCE: Bureau of Labor Statistics, unpublished tabulations, February 1993.

See figure 6-1.

Appendix table 6–4.
Global production, exports, and imports of manufactured products, by region/country and industry: 1981–92
(page 1 of 7)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Millions of constant 1980 U.S. dollars												
All manufacturing industries												
Production												
United States	1,816,555	1,727,457	1,787,977	1,941,314	1,952,791	1,968,889	2,134,640	2,233,440	2,299,095	2,301,184	2,294,635	2,410,674
Japan	975,165	1,021,451	1,082,074	1,126,781	1,234,646	1,211,675	1,234,999	1,346,133	1,394,714	1,466,379	1,510,967	1,557,773
Germany[1]	645,455	657,401	675,429	719,703	784,182	788,035	777,233	813,454	869,518	904,326	912,062	942,356
France	422,663	438,190	445,578	462,981	502,334	498,535	493,441	511,873	531,454	553,971	562,747	577,889
United Kingdom	381,665	388,985	403,296	437,280	463,628	464,906	508,941	538,278	547,462	560,640	547,768	558,695
Italy	253,048	246,502	260,316	282,501	282,794	297,494	302,271	325,206	332,900	332,468	331,042	338,779
Other OECD countries[2]	890,457	969,895	1,045,779	1,096,526	1,183,836	1,204,745	1,228,360	1,252,320	1,275,700	1,308,486	1,318,710	1,350,006
European Community	2,058,816	2,133,567	2,233,775	2,370,148	2,531,708	2,534,093	2,577,138	2,694,723	2,801,948	2,887,152	2,900,234	2,979,178
OECD[2]	5,385,008	5,449,880	5,700,450	6,067,084	6,404,212	6,434,280	6,679,884	7,020,704	7,250,842	7,427,453	7,477,931	7,736,172
Exports												
United States	162,207	144,737	138,326	149,678	155,790	166,199	195,167	239,401	261,971	276,361	290,610	306,206
Japan	141,957	141,802	158,543	191,380	210,860	223,799	235,228	258,234	281,667	305,389	314,729	346,592
Germany[1]	192,977	204,644	209,397	235,139	268,082	277,341	285,807	302,376	338,670	354,756	347,646	370,001
France	104,278	105,566	111,743	122,697	132,736	137,335	147,297	159,425	176,142	195,177	205,398	219,544
United Kingdom	84,290	90,230	94,603	107,357	122,243	145,338	161,634	177,534	192,954	211,990	206,967	223,381
Italy	79,082	82,380	88,065	95,957	108,935	115,888	120,189	128,940	143,359	155,709	149,902	155,713
Other OECD countries[2]	333,051	349,322	387,577	436,102	494,031	543,886	586,267	616,953	660,227	747,431	767,879	830,070
European Community	631,382	663,280	705,206	783,504	879,024	950,793	1,012,349	1,088,550	1,204,901	1,325,895	1,326,171	1,417,135
OECD[2]	1,097,840	1,118,681	1,188,254	1,338,311	1,492,677	1,609,786	1,731,588	1,882,862	2,054,990	2,246,813	2,283,132	2,451,506
Imports												
United States	170,467	162,503	187,671	247,880	271,258	309,343	339,677	358,463	388,515	394,644	404,039	449,361
Japan	52,759	57,548	64,622	76,330	83,549	115,874	148,302	184,151	207,730	218,055	224,568	246,949
Germany[1]	129,181	133,170	151,395	167,306	189,517	222,150	241,565	258,571	294,147	361,418	419,635	446,663
France	90,218	98,870	106,060	112,164	129,170	161,742	182,877	203,277	222,618	250,774	247,606	269,115
United Kingdom	89,655	100,355	116,975	136,496	148,685	172,449	193,658	226,448	252,546	264,529	249,562	272,767
Italy	57,312	61,139	64,658	77,234	87,273	107,056	123,824	135,654	146,418	162,054	160,506	176,578
Other OECD countries[2]	333,213	341,923	374,306	425,941	500,915	599,796	662,597	725,882	804,278	881,423	912,545	979,200
European Community	522,610	557,813	619,053	690,098	779,776	942,270	1,055,755	1,169,273	1,300,759	1,478,859	1,540,497	1,665,741
OECD[2]	922,805	955,508	1,065,688	1,243,350	1,410,368	1,688,410	1,892,501	2,092,445	2,316,252	2,532,897	2,618,463	2,840,633
High-tech industries[3]												
Production												
United States	278,422	287,908	306,194	368,557	388,512	414,323	458,020	503,057	539,731	560,368	585,832	640,189
Japan	161,740	171,012	200,228	252,500	283,169	301,317	328,936	385,433	400,394	428,420	457,401	480,694
Germany[1]	87,798	88,247	94,054	103,720	121,746	128,605	132,245	143,061	155,420	163,129	165,723	175,224
France	49,481	49,811	51,389	55,807	64,573	67,993	68,826	74,225	76,722	81,522	85,365	88,881
United Kingdom	52,147	53,584	57,401	66,931	76,980	83,365	94,019	108,159	106,717	111,668	109,190	112,893
Italy	28,962	29,180	30,992	31,560	32,183	40,525	43,301	50,808	52,858	55,163	54,796	56,601
Other OECD countries[2]	83,863	87,796	99,705	106,813	119,548	132,392	137,812	145,945	148,347	156,073	160,017	165,791
European Community	247,618	253,889	273,484	303,294	345,521	372,949	391,301	432,227	450,276	473,250	479,823	501,226
OECD[2]	742,418	767,536	839,963	985,885	1,086,708	1,168,521	1,263,155	1,410,689	1,480,188	1,556,344	1,618,322	1,720,274

(continued)

Appendix table 6–4.

Global production, exports, and imports of manufactured products, by region/country and industry: 1981–92

(page 2 of 7)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
						Millions of constant 1980 U.S. dollars						
Exports												
United States	46,042	43,647	48,019	56,153	63,953	73,459	90,271	115,235	126,749	136,101	141,167	148,687
Japan	38,370	38,745	50,864	69,928	80,895	95,042	106,579	128,006	144,565	159,721	167,979	190,179
Germany[1]	32,545	35,857	37,400	44,924	55,486	61,041	64,796	71,304	84,818	90,829	91,538	97,560
France	15,646	18,527	19,465	23,535	27,263	30,354	35,835	40,130	47,054	52,476	58,035	63,531
United Kingdom	16,556	19,385	22,299	28,892	37,066	46,341	52,858	65,887	75,468	80,333	78,774	87,733
Italy	9,207	9,904	11,078	13,044	17,039	19,155	20,579	24,999	30,320	33,066	28,957	28,769
Other OECD countries[2]	40,990	43,214	49,858	60,614	75,064	91,834	106,567	119,503	139,570	178,169	175,966	195,321
European Community	93,398	104,304	114,780	141,412	175,519	206,425	233,081	269,992	320,843	368,541	364,567	396,423
OECD[2]	199,356	209,280	238,984	297,090	356,768	417,228	477,481	565,068	648,547	730,696	742,417	811,778
Imports												
United States	29,532	29,845	38,211	57,755	66,333	84,728	101,962	123,266	142,459	152,660	168,090	195,695
Japan	7,600	7,735	9,788	11,948	14,721	20,953	25,770	36,056	46,004	52,564	57,094	66,780
Germany[1]	23,914	25,376	29,597	35,566	44,749	56,064	65,825	77,914	97,565	126,269	143,843	160,420
France	14,704	16,466	19,069	22,146	28,126	39,231	47,643	59,769	67,609	79,920	78,781	88,178
United Kingdom	16,743	19,838	26,236	34,169	41,590	50,226	60,028	76,314	91,748	100,135	99,192	110,513
Italy	9,440	9,793	10,869	14,855	18,761	25,309	31,481	39,233	41,693	48,967	48,678	54,869
Other OECD countries[2]	55,169	56,786	68,575	87,552	112,137	147,580	172,695	211,500	248,719	286,414	303,330	331,629
European Community	149,868	161,925	184,351	229,147	264,234	313,867	365,268	435,634	501,551	573,657	603,600	662,062
OECD[2]	195,787	207,966	250,897	332,613	388,522	474,824	550,754	678,449	783,565	893,753	955,211	1,059,992
						Drugs and medicines (ISIC 3522)						
Production												
United States	18,372	19,423	19,895	20,285	19,954	22,379	24,025	25,199	25,324	26,094	26,902	27,199
Japan	13,469	14,104	14,374	14,056	13,716	14,967	16,002	16,431	17,582	18,812	19,722	20,379
Germany[1]	8,154	7,987	8,165	8,459	8,222	8,920	8,775	8,985	9,428	10,059	10,443	10,595
France	3,276	2,999	2,889	2,844	2,671	2,845	2,772	2,802	2,998	3,139	3,197	3,271
United Kingdom	5,492	5,792	5,740	6,057	6,032	6,835	7,150	7,428	7,948	8,262	8,258	8,335
Italy	3,373	3,576	3,640	4,112	4,393	4,319	4,077	4,533	4,850	5,075	5,058	5,070
Other OECD countries[2]	10,413	11,313	11,823	11,777	11,257	12,531	13,054	13,467	14,410	15,024	15,434	15,883
European Community	24,870	25,374	25,658	26,667	26,689	28,583	28,579	29,785	31,684	33,320	33,944	34,431
OECD[2]	62,550	65,194	66,526	67,589	66,244	72,798	75,856	78,846	82,540	86,465	89,014	90,731
Exports												
United States	2,053	1,985	2,031	2,033	1,925	2,295	2,247	2,575	2,088	2,335	2,644	2,725
Japan	311	302	341	344	366	428	435	462	483	574	633	655
Germany[1]	2,489	2,502	2,550	2,756	2,910	3,224	3,235	3,322	3,427	3,802	4,201	4,294
France	1,586	3,041	1,712	1,756	1,828	2,035	2,038	2,073	2,309	2,645	2,939	3,083
United Kingdom	1,772	1,936	1,927	2,037	2,162	2,748	2,728	2,682	2,778	3,175	3,461	3,638
Italy	747	764	793	872	960	1,015	967	981	917	1,041	1,025	1,029
Other OECD countries[2]	4,802	4,861	5,183	5,373	5,652	6,726	7,128	7,358	7,758	9,121	9,896	10,414
European Community	8,699	10,460	9,361	9,964	10,475	12,176	12,406	12,739	13,229	15,138	16,566	17,272
OECD[2]	13,760	15,390	14,537	15,170	15,803	18,472	18,777	19,453	19,761	22,694	24,799	25,838

(continued)

Appendix table 6–4.

Global production, exports, and imports of manufactured products, by region/country and industry: 1981–92

(page 3 of 7)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	Millions of constant 1980 U.S. dollars											
Imports												
United States	836	764	921	1,119	1,185	1,489	1,677	2,011	1,224	1,341	1,575	1,636
Japan	1,114	1,216	1,270	1,332	1,376	2,178	2,412	2,736	2,631	2,619	2,927	3,156
Germany[1]	1,307	1,315	1,372	1,483	1,598	1,995	2,060	2,078	2,186	2,636	3,253	3,295
France	764	786	854	868	925	1,209	1,288	1,498	1,721	2,073	2,358	2,480
United Kingdom	649	752	861	910	906	1,177	1,295	1,361	1,515	1,676	1,876	1,962
Italy	687	711	826	931	1,035	1,447	1,445	1,688	1,721	2,067	2,258	2,417
Other OECD countries[2]	4,089	4,146	4,444	4,611	4,946	6,433	6,894	6,976	7,198	8,475	9,140	9,527
European Community	5,485	5,633	6,125	6,427	6,784	8,902	9,352	9,978	10,654	12,657	14,382	15,031
OECD[2]	9,447	9,690	10,549	11,253	11,971	15,928	17,070	18,348	18,196	20,888	23,387	24,474
Office and computing machinery (ISIC 3825)												
Production												
United States	35,496	43,187	60,802	90,639	108,463	124,475	146,853	174,577	201,076	217,612	239,173	285,020
Japan	16,615	20,999	36,445	56,257	82,127	101,093	124,004	154,181	164,973	176,521	188,878	202,099
Germany[1]	5,378	6,148	9,371	15,173	22,722	26,356	27,356	32,064	35,276	37,746	37,660	40,296
France	3,294	3,854	5,705	8,782	10,661	12,267	12,620	14,764	15,797	16,903	18,086	19,352
United Kingdom	3,408	4,279	7,069	11,922	19,096	21,716	29,113	40,553	39,911	42,705	44,395	47,503
Italy	1,385	1,406	2,477	3,423	3,564	10,533	11,307	17,669	18,906	20,229	20,384	21,811
Other OECD countries[2]	5,554	7,923	11,896	18,683	25,671	30,717	31,488	34,246	34,705	36,982	39,268	41,939
European Community	15,190	19,091	30,356	49,571	69,156	85,988	95,288	121,238	127,044	135,936	140,102	149,909
OECD[2]	71,130	87,795	133,765	204,878	272,305	327,157	382,739	468,053	510,645	548,698	587,843	658,020
Exports												
United States	9,957	11,073	16,022	23,892	30,469	37,531	49,376	66,925	73,707	77,245	80,168	84,297
Japan	4,579	6,069	12,096	21,019	29,192	41,703	52,592	67,781	81,169	91,718	98,960	115,848
Germany[1]	4,181	4,993	7,592	10,940	17,815	22,492	24,765	27,140	34,968	37,384	37,231	39,211
France	2,332	2,610	4,270	6,330	9,068	12,691	16,360	18,168	22,475	23,913	25,855	28,038
United Kingdom	3,016	4,105	6,439	11,172	16,855	21,868	29,772	39,793	47,953	48,681	47,402	53,940
Italy	1,436	1,843	2,595	3,716	6,932	8,385	9,194	12,344	16,766	17,550	13,950	12,918
Other OECD countries[2]	5,554	7,153	12,156	19,543	28,780	38,905	49,633	58,234	72,951	86,078	90,560	103,001
European Community	14,164	17,880	28,338	45,033	69,533	91,392	113,332	136,110	173,267	187,222	187,574	205,418
OECD[2]	31,054	37,848	61,171	96,612	139,112	183,575	231,690	290,385	349,990	382,570	394,126	437,253
Imports												
United States	3,733	4,792	9,599	18,324	24,336	36,892	50,264	65,429	83,481	93,777	107,549	128,432
Japan	1,146	1,366	1,956	3,227	4,955	7,457	10,140	15,961	23,628	28,144	30,946	36,987
Germany[1]	4,315	5,009	8,332	12,585	19,585	26,891	33,128	41,000	55,468	73,657	82,837	91,974
France	3,340	4,608	6,933	9,542	14,258	21,061	26,582	34,121	40,846	48,214	45,183	51,820
United Kingdom	4,009	5,525	9,691	15,184	20,539	26,947	35,279	46,595	60,410	67,052	68,027	76,616
Italy	1,933	2,213	3,170	5,455	8,491	11,938	15,903	20,695	22,047	25,837	24,801	28,430
Other OECD countries[2]	10,930	13,700	21,962	36,031	52,735	72,934	92,728	117,982	145,263	168,953	181,442	200,627
European Community	17,887	23,057	37,851	59,184	86,902	120,765	153,792	198,435	247,490	300,239	312,168	351,071
OECD[2]	29,406	37,212	61,644	100,348	144,899	204,120	264,023	341,783	431,143	505,634	540,785	614,886

(continued)

Appendix table 6–4.

Global production, exports, and imports of manufactured products, by region/country and industry: 1981–92

(page 4 of 7)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	Millions of constant 1980 U.S. dollars											
	Electrical machinery (ISIC 383 less 3832)											
Production												
United States	59,852	55,526	57,292	65,447	63,772	63,586	67,338	70,599	71,385	69,868	66,578	69,002
Japan	48,135	49,061	52,888	59,092	63,619	63,732	67,289	74,667	79,493	85,057	90,409	94,305
Germany[1]	36,169	34,572	36,944	38,470	41,967	42,896	46,253	48,854	52,185	54,416	55,926	59,136
France	16,167	15,635	15,710	16,532	18,962	19,163	20,304	21,109	21,997	23,213	23,982	24,516
United Kingdom	14,188	14,304	14,622	15,718	16,491	16,859	17,968	18,855	19,631	20,628	20,188	20,718
Italy	12,469	12,556	13,668	12,974	12,968	14,292	16,219	16,597	17,147	17,570	17,279	17,348
Other OECD countries[2]	31,147	30,941	34,804	33,093	34,680	37,015	39,978	42,110	44,028	46,129	46,630	47,832
European Community	88,612	87,362	92,301	94,838	101,735	104,926	113,861	119,068	125,346	130,966	133,187	138,099
OECD[2]	218,128	212,594	225,928	241,327	252,458	257,542	275,348	292,792	305,865	316,881	320,993	332,857
Exports												
United States	8,618	9,483	9,802	11,144	9,873	10,678	12,787	16,166	17,373	18,872	19,806	21,495
Japan	10,023	9,841	12,305	16,507	16,123	17,094	18,920	22,803	24,886	25,826	27,549	30,595
Germany[1]	10,893	11,405	11,681	13,276	15,046	16,052	16,798	19,045	21,286	23,266	24,317	26,207
France	5,091	5,269	5,639	6,243	6,718	6,972	7,501	8,282	8,610	10,046	11,035	11,840
United Kingdom	3,667	4,261	4,346	5,105	5,972	6,698	7,411	8,551	8,896	10,116	9,916	10,687
Italy	3,739	3,817	4,142	4,313	4,597	5,039	5,660	6,587	7,020	7,649	7,842	8,171
Other OECD countries[2]	11,136	11,469	12,067	13,717	15,537	17,826	19,558	21,697	22,992	26,177	27,566	29,897
European Community	29,106	30,621	31,964	35,833	40,036	43,833	47,174	53,354	57,705	63,777	66,161	70,954
OECD[2]	53,167	55,544	59,981	70,306	73,866	80,359	88,635	103,132	111,062	121,953	128,030	138,892
Imports												
United States	8,669	8,941	10,791	15,475	14,791	16,590	19,855	23,840	24,563	25,317	26,210	28,753
Japan	1,792	1,920	2,268	3,108	3,081	4,007	4,933	6,641	7,770	8,985	10,358	11,794
Germany[1]	5,949	5,948	6,626	8,117	9,035	10,541	11,745	13,483	14,910	17,997	20,249	21,544
France	4,185	4,528	4,738	5,411	5,974	7,562	8,885	10,396	10,706	12,455	13,135	14,267
United Kingdom	3,853	4,478	5,463	7,076	7,682	8,566	9,747	11,476	12,372	13,331	13,482	14,493
Italy	2,265	2,387	2,534	3,271	3,487	4,549	5,508	6,955	7,186	8,074	8,146	8,915
Other OECD countries[2]	14,976	15,230	16,568	19,714	22,565	27,132	30,224	36,167	39,441	44,020	45,478	48,797
European Community	22,782	23,941	26,391	31,912	35,125	42,773	48,813	57,406	61,788	70,779	75,046	80,775
OECD[2]	41,688	43,431	48,988	62,172	66,614	78,948	90,895	108,959	116,948	130,178	137,058	148,561
	Communication equipment (ISIC 3832)											
Production												
United States	75,621	80,577	84,226	100,718	100,707	101,425	110,557	118,747	123,996	124,185	127,888	130,831
Japan	66,221	70,243	79,506	105,089	103,481	101,871	102,223	119,203	118,430	126,720	135,590	139,970
Germany[1]	24,822	26,219	27,508	29,201	34,579	35,900	34,662	36,896	40,392	41,841	41,711	43,816
France	11,095	11,857	11,697	12,549	15,624	16,038	15,216	15,942	17,058	18,092	18,691	19,128
United Kingdom	14,181	14,947	16,262	19,471	19,685	20,025	20,861	22,303	23,061	23,449	22,270	22,242
Italy	4,219	4,344	4,698	4,478	4,467	4,886	4,915	6,794	6,822	6,992	6,839	6,909
Other OECD countries[2]	21,397	22,743	25,433	27,381	29,914	32,534	32,203	33,879	34,809	36,568	37,597	38,733
European Community	64,426	67,983	72,748	79,593	89,344	92,682	90,436	97,435	103,449	107,138	107,064	110,249
OECD[2]	217,557	230,930	249,331	298,886	308,457	312,679	320,636	353,765	364,568	377,847	390,586	401,630

(continued)

Appendix table 6–4.
Global production, exports, and imports of manufactured products, by region/country and industry: 1981–92
(page 5 of 7)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	Millions of constant 1980 U.S. dollars											
Exports												
United States	3,690	3,540	3,356	3,416	3,562	3,765	4,305	5,533	6,412	6,670	6,769	6,295
Japan	16,001	15,444	18,077	22,981	25,069	24,916	23,507	24,754	24,992	27,507	26,492	27,689
Germany[1]	4,248	4,434	4,247	4,698	5,314	5,874	6,225	6,061	6,694	6,997	5,762	6,339
France	1,401	1,592	1,912	2,008	2,337	2,304	2,709	2,767	3,285	5,085	5,779	6,657
United Kingdom	1,801	1,948	2,013	2,180	2,449	3,021	3,339	3,833	4,569	6,217	6,829	7,665
Italy	840	1,022	1,043	1,254	1,368	1,510	1,443	1,403	1,529	1,920	1,563	1,762
Other OECD countries[2]	7,056	7,245	7,392	8,184	9,128	10,436	11,257	11,659	12,883	30,050	20,169	22,137
European Community	11,785	12,178	12,387	13,365	14,941	17,251	18,761	19,232	21,556	42,508	32,787	36,283
OECD[2]	35,037	35,226	38,039	44,720	49,227	51,829	52,784	56,012	60,365	84,445	73,364	78,543
Imports												
United States	8,815	8,567	10,344	14,349	16,434	18,162	18,073	18,923	19,712	18,853	19,015	21,938
Japan	471	505	549	643	695	1,143	1,736	2,678	3,577	2,603	3,328	4,214
Germany[1]	3,269	3,374	3,734	3,990	4,182	5,362	6,593	7,534	8,250	12,852	13,138	13,651
France	2,010	2,189	1,939	1,947	2,098	3,097	3,816	4,681	4,995	6,272	6,328	6,985
United Kingdom	2,966	3,493	3,973	3,632	4,073	4,998	5,837	6,891	7,755	8,104	6,402	7,136
Italy	1,417	1,491	1,347	1,585	1,780	2,498	3,117	3,832	3,908	4,888	4,446	5,124
Other OECD countries[2]	8,586	8,495	9,069	10,322	12,113	15,878	17,698	20,267	22,465	26,323	26,732	29,014
European Community	75,621	80,577	84,226	100,718	100,707	101,425	110,557	118,747	123,996	124,185	127,888	130,831
OECD[2]	66,221	70,243	79,506	105,089	103,481	101,871	102,223	119,203	118,430	126,720	135,590	139,970
	Aircraft (ISIC 3845)											
Production												
United States	50,162	48,118	43,840	48,728	51,913	58,185	62,553	63,331	65,391	67,922	69,571	70,178
Japan	2,108	1,983	1,883	2,036	2,575	2,470	2,907	3,057	2,889	3,092	3,308	3,540
Germany[1]	4,734	5,093	4,247	4,156	4,476	4,321	4,961	4,909	6,601	7,063	7,557	8,086
France	12,388	12,027	11,884	11,337	11,769	12,582	12,540	13,774	13,561	14,510	15,526	16,596
United Kingdom	11,120	9,939	9,812	9,693	11,071	13,094	13,851	13,415	11,017	11,115	8,863	9,089
Italy	3,134	3,034	2,420	2,454	3,037	2,747	3,152	3,298	3,366	3,601	3,563	3,788
Other OECD countries[2]	5,243	4,812	4,450	4,700	5,565	6,292	6,380	6,627	5,748	5,781	5,288	5,322
European Community	32,796	31,687	29,653	28,866	31,809	34,344	36,260	37,258	36,478	38,356	37,586	39,720
OECD[2]	88,890	85,006	78,536	83,103	90,405	99,691	106,344	108,411	108,573	113,084	113,676	116,600
Exports												
United States	13,541	9,741	9,536	8,214	10,554	11,196	13,098	14,219	15,935	18,788	18,804	19,956
Japan	114	155	148	127	119	126	181	222	282	345	360	401
Germany[1]	3,990	5,350	4,033	4,914	4,413	2,873	3,143	4,288	6,301	6,477	7,041	7,723
France	2,307	3,025	2,707	3,560	3,105	2,405	2,913	4,157	5,661	5,435	6,875	7,986
United Kingdom	2,799	3,215	3,400	3,574	3,928	5,157	2,588	3,488	3,571	3,481	2,939	3,147
Italy	1,173	1,160	1,064	1,260	1,276	1,052	1,047	1,346	1,544	2,115	1,804	1,946
Other OECD countries[2]	2,612	2,533	2,301	2,130	2,598	3,183	3,411	4,682	5,796	7,093	7,555	8,457
European Community	11,487	13,862	12,287	14,070	13,474	12,280	10,706	15,697	20,385	21,354	22,680	25,334
OECD[2]	26,537	25,179	23,190	23,780	25,993	25,991	26,380	32,402	39,091	43,734	45,379	49,616

(continued)

Appendix table 6–4.

Global production, exports, and imports of manufactured products, by region/country and industry: 1981–92

(page 6 of 7)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	Millions of constant 1980 U.S. dollars											
Imports												
United States	2,598	2,278	1,644	2,289	2,667	3,355	3,314	3,678	3,960	3,819	4,170	4,886
Japan	1,318	816	1,551	1,003	1,713	2,365	2,191	2,395	1,924	3,243	2,924	3,109
Germany[1]	4,806	5,412	5,042	4,483	4,556	4,267	4,667	5,679	8,051	8,478	11,739	16,707
France	1,263	959	1,041	738	722	1,143	1,256	2,724	2,684	3,302	3,994	4,160
United Kingdom	1,580	1,608	1,736	2,142	2,682	2,030	1,093	2,625	1,686	1,372	1,242	1,395
Italy	985	748	693	1,043	1,132	1,138	1,120	1,160	1,598	2,151	2,374	2,594
Other OECD countries[2]	5,495	3,933	4,765	3,878	4,488	5,885	5,314	9,081	11,370	12,686	13,451	14,363
European Community	10,457	10,224	10,164	9,609	10,381	10,008	9,807	15,183	19,154	21,191	26,079	32,366
OECD[2]	18,044	15,754	16,471	15,576	17,960	20,183	18,955	27,341	31,272	35,051	39,895	47,214
Scientific instruments (ISIC 385)												
Production												
United States	38,919	41,077	40,139	42,740	43,703	44,273	46,694	50,604	52,559	54,687	55,720	57,959
Japan	15,192	14,622	15,132	15,970	17,651	17,184	16,511	17,894	17,027	18,218	19,494	20,401
Germany[1]	8,541	8,228	7,819	8,261	9,780	10,212	10,238	11,353	11,538	12,004	12,426	13,295
France	3,261	3,439	3,504	3,763	4,886	5,098	5,374	5,834	5,311	5,665	5,883	6,018
United Kingdom	3,758	4,323	3,896	4,070	4,605	4,836	5,076	5,605	5,149	5,509	5,216	5,006
Italy	4,382	4,264	4,089	4,119	3,754	3,748	3,631	1,917	1,767	1,696	1,673	1,675
Other OECD countries[2]	10,109	10,064	11,299	11,179	12,461	13,303	14,709	15,616	14,647	15,589	15,800	16,082
European Community	21,724	22,392	22,768	23,759	26,788	26,426	26,877	27,443	26,275	27,534	27,940	28,818
OECD[2]	84,163	86,017	85,877	90,102	96,839	98,654	102,232	108,822	107,997	113,369	116,210	120,436
Exports												
United States	8,183	7,825	7,272	7,454	7,570	7,994	8,458	9,817	11,234	12,191	12,976	13,919
Japan	7,342	6,934	7,897	8,950	10,026	10,775	10,944	11,984	12,753	13,751	13,985	14,991
Germany[1]	6,744	7,173	7,297	8,340	9,988	10,526	10,630	11,448	12,142	12,903	12,986	13,786
France	2,929	2,990	3,225	3,638	4,207	3,947	4,314	4,683	4,714	5,352	5,552	5,927
United Kingdom	3,501	3,920	4,174	4,824	5,700	6,849	7,020	7,540	7,701	8,663	8,227	8,656
Italy	1,272	1,298	1,441	1,629	1,906	2,154	2,268	2,338	2,544	2,791	2,773	2,943
Other OECD countries[2]	9,830	9,953	10,759	11,667	13,369	14,758	15,580	15,873	17,190	19,650	20,220	21,415
European Community	18,157	19,303	20,443	23,147	27,060	29,493	30,702	32,860	34,701	38,542	38,799	41,162
OECD[2]	39,801	40,093	42,066	46,502	52,767	57,002	59,215	63,684	68,278	75,300	76,719	81,636
Imports												
United States	4,881	4,503	4,912	6,199	6,920	8,240	8,779	9,385	9,519	9,553	9,571	10,050
Japan	1,759	1,912	2,194	2,635	2,901	3,803	4,358	5,645	6,474	6,970	6,611	7,520
Germany[1]	4,268	4,318	4,491	4,908	5,793	7,008	7,632	8,140	8,700	10,649	12,627	13,249
France	3,142	3,396	3,564	3,640	4,149	5,159	5,816	6,349	6,657	7,604	7,783	8,466
United Kingdom	3,686	3,982	4,512	5,225	5,708	6,508	6,777	7,366	8,010	8,600	8,163	8,911
Italy	2,153	2,243	2,299	2,570	2,836	3,739	4,388	4,903	5,233	5,950	6,653	7,389
Other OECD countries[2]	11,093	11,282	11,767	12,996	15,290	19,318	19,837	21,027	22,982	25,957	27,087	29,301
European Community	17,636	18,493	19,594	21,297	24,335	29,994	32,947	35,885	38,469	44,606	48,037	51,988
OECD[2]	30,981	31,636	33,739	38,175	43,597	53,774	57,588	62,815	67,576	75,282	78,496	84,887

(continued)

Appendix table 6–4.

Global production, exports, and imports of manufactured products, by region/country and industry: 1981–92

(page 7 of 7)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	Millions of constant 1980 U.S. dollars											
	Other industries[4]											
Production												
United States	1,538,133	1,439,549	1,481,783	1,572,757	1,564,279	1,554,566	1,676,620	1,730,383	1,759,364	1,740,816	1,708,803	1,770,485
Japan	813,425	850,439	881,846	874,281	951,477	910,358	906,063	960,700	994,320	1,037,959	1,053,566	1,077,079
Germany[1]	557,657	569,154	581,375	615,983	662,436	659,430	644,988	670,393	714,098	741,197	746,339	767,132
France	373,182	388,379	394,189	407,174	437,761	430,542	424,615	437,648	454,732	472,449	477,382	489,008
United Kingdom	329,518	335,401	345,895	370,349	386,648	381,541	414,922	430,119	440,745	448,972	438,578	445,802
Italy	224,086	217,322	229,324	250,941	250,611	256,969	258,970	274,398	280,042	277,305	276,246	282,178
Other OECD countries[2]	806,594	882,099	946,074	989,713	1,064,288	1,072,353	1,090,548	1,106,375	1,127,353	1,152,413	1,158,693	1,184,215
European Community	1,811,198	1,879,678	1,960,291	2,066,854	2,186,187	2,161,144	2,185,837	2,262,496	2,351,672	2,413,902	2,420,411	2,477,952
OECD[2]	4,642,590	4,682,344	4,860,487	5,081,199	5,317,504	5,265,759	5,416,729	5,610,015	5,770,654	5,871,109	5,859,609	6,015,898
Exports												
United States	116,165	101,090	90,307	93,525	91,837	92,740	104,896	124,166	135,222	140,260	149,443	157,519
Japan	103,587	103,057	107,679	121,452	129,965	128,757	128,649	130,228	137,102	145,668	146,750	156,413
Germany[1]	160,432	168,787	171,997	190,215	212,596	216,300	221,011	231,072	253,852	263,927	256,108	272,441
France	88,632	87,039	92,278	99,162	105,473	106,981	111,462	119,295	129,088	142,701	147,363	156,013
United Kingdom	67,734	70,845	72,304	78,465	85,177	98,997	108,776	111,647	117,486	131,657	128,193	135,648
Italy	69,875	72,476	76,987	82,913	91,896	96,733	99,610	103,941	113,039	122,643	120,945	126,944
Other OECD countries[2]	292,061	306,108	337,719	375,488	418,967	452,052	479,700	497,450	520,657	569,262	591,913	634,749
European Community	537,984	558,976	590,426	642,092	703,505	744,368	779,268	818,558	884,058	957,354	961,604	1,020,712
OECD[2]	898,484	909,401	949,270	1,041,221	1,135,909	1,192,558	1,254,107	1,317,794	1,406,443	1,516,117	1,540,715	1,639,728
Imports												
United States	140,935	132,658	149,460	190,125	204,925	224,615	237,715	235,197	246,056	241,984	235,949	253,666
Japan	45,159	49,813	54,834	64,382	68,828	94,921	122,532	148,095	161,726	165,491	167,474	180,169
Germany[1]	105,267	107,794	121,798	131,740	144,768	166,086	175,740	180,657	196,582	235,149	275,792	286,243
France	75,514	82,404	86,991	90,018	101,044	122,511	135,234	143,508	155,009	170,854	168,825	180,937
United Kingdom	72,912	80,517	90,739	102,327	107,095	122,223	133,630	150,134	160,798	164,394	150,370	162,254
Italy	47,872	51,346	53,789	62,379	68,512	81,747	92,343	96,421	104,725	113,087	111,828	121,709
Other OECD countries[2]	278,044	285,137	305,731	338,389	388,778	452,216	489,902	514,382	555,559	595,009	609,215	647,571
European Community	372,742	395,888	434,702	460,951	515,542	628,403	690,487	733,639	799,208	905,202	936,897	1,003,679
OECD[2]	727,018	747,542	814,791	910,737	1,021,846	1,213,586	1,341,747	1,413,996	1,532,687	1,639,144	1,663,252	1,780,641

ISIC = international standard industrial classification; OECD = Organisation for Economic Co-operation and Development

NOTES: Values for the period 1989–92 are estimates based on the growth rate of the producing industry for each product category in each country (historical data or forecast where not yet reported) from DRI/McGraw-Hill forecasting services. Import (c.i.f.) and export (f.o.b.) data were retrieved from the OECD Trade Series database in three-digit standard international trade classification (SITC) Revision 2 codes. They were then grouped to the ISIC products using the concordance between the ISIC codes and the SITC Revision 2 codes. Data were in U.S. dollars.

[1] German data are for the former West Germany only.

[2] The 24 OECD member countries are Australia, Austria, Belgium/Luxembourg, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, The Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

[3] OECD's standard definition of high-technology industries identifies six industries with high R&D intensities (ratio of R&D performed by industry to the value of gross output). This definition was established in 1986 using 1980 data. OECD reviewed the R&D intensities using preliminary 1989 data which reconfirmed the industries selected in 1986.

[4] Other manufacturing industries are all manufacturing industries less the high-tech industries listed above.

SOURCE: OECD, Industrial Structure Statistics and Series C Trade Data (Paris); special tabulations by DRI/McGraw-Hill, 1993.

See figures 6–2, 6–3, 6–4, 6–5, 6–6, 6–7, 6–8, 6–9, and 6–10.

Appendix table 6-5.
Import share of domestic market for high-tech manufactures, by industry: 1981–92
(page 1 of 2)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	Percent											
All high-tech manufactures												
United States	11.3	10.9	12.9	15.6	17.0	19.9	21.7	24.1	25.7	26.5	27.5	28.5
Japan	5.8	5.5	6.2	6.1	6.8	9.2	10.4	12.3	15.2	16.4	16.5	18.7
Germany[1]	30.2	32.6	34.3	37.7	40.3	45.3	49.4	52.1	58.0	63.6	66.0	67.4
France	30.3	34.5	37.4	40.7	43.0	51.0	59.1	63.7	69.5	73.3	74.2	77.7
United Kingdom	32.0	36.7	42.8	47.3	51.0	57.6	59.3	64.3	74.6	76.2	76.5	81.5
Italy	32.3	33.7	35.3	44.5	55.3	54.2	58.1	60.3	64.9	68.9	65.3	66.4
Drugs and medicines (ISIC 3522)												
United States	4.9	4.2	4.9	5.8	6.2	6.9	7.1	8.2	5.0	5.3	6.1	6.3
Japan	7.8	8.1	8.3	8.9	9.3	13.0	13.4	14.6	13.3	12.6	13.3	13.8
Germany[1]	18.7	19.3	19.6	20.6	23.1	25.9	27.1	26.8	26.7	29.6	34.3	34.3
France	31.1	105.6	42.0	44.4	52.3	59.9	63.7	67.3	71.4	80.8	90.1	93.0
United Kingdom	14.9	16.3	18.4	18.5	19.0	22.4	22.7	22.3	22.7	24.8	28.1	29.5
Italy	20.7	20.2	22.5	22.3	23.2	30.5	31.7	32.2	30.4	33.9	35.9	37.4
Office and computing machinery (ISIC 3825)												
United States	12.8	13.0	17.7	21.5	23.8	29.8	34.0	37.8	39.6	40.1	40.3	39.0
Japan	8.7	8.4	7.4	8.4	8.6	11.2	12.4	15.6	22.0	24.9	25.6	30.0
Germany[1]	78.3	81.3	82.4	74.8	80.0	87.4	92.7	89.3	99.4	99.5	99.5	98.8
France	77.6	78.7	82.9	79.6	90.0	102.1	116.4	111.1	119.5	117.0	120.8	120.1
United Kingdom	91.1	96.9	93.9	95.3	90.2	100.6	101.9	98.4	115.4	109.8	104.6	109.2
Italy	102.7	124.6	103.9	105.7	165.7	84.8	88.3	79.5	91.2	90.6	79.4	76.2
Electrical machinery (ISIC 383 less 3832)												
United States	14.5	16.3	18.5	22.2	21.5	23.9	26.7	30.5	31.3	33.2	35.9	37.7
Japan	4.5	4.7	5.3	6.8	6.1	7.9	9.3	11.4	12.5	13.2	14.1	15.6
Germany[1]	19.1	20.4	20.8	24.4	25.1	28.2	28.5	31.1	32.5	36.6	39.0	39.5
France	27.4	30.4	32.0	34.5	32.8	38.3	41.0	44.8	44.4	48.6	50.4	53.0
United Kingdom	26.8	30.8	34.7	40.0	42.2	45.7	48.0	52.7	53.5	55.9	56.8	59.1
Italy	20.6	21.5	21.0	27.4	29.4	33.0	34.3	41.0	41.5	44.9	46.3	49.3
Communication equipment (ISIC 3832)												
United States	10.9	10.0	11.3	12.9	14.5	15.7	14.5	14.3	14.4	13.8	13.6	15.0
Japan	0.9	0.9	0.9	0.8	0.9	1.5	2.2	2.8	3.7	2.6	3.0	3.6
Germany[1]	13.7	13.4	13.8	14.0	12.5	15.2	18.8	19.6	19.7	26.9	26.8	26.7
France	17.2	17.6	16.5	15.6	13.6	18.4	23.4	26.2	26.6	32.5	32.9	35.9
United Kingdom	19.3	21.2	21.8	17.4	19.1	22.7	25.0	27.2	29.5	32.0	29.3	32.9
Italy	29.5	31.0	26.9	33.0	36.5	42.5	47.3	41.5	42.5	49.1	45.7	49.9

(continued)

Appendix table 6–5.

Import share of domestic market for high -tech manufactures, by industry: 1981–92

(page 2 of 2)

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
	Percent											
Aircraft (ISIC 3845)												
United States	6.6	5.6	4.6	5.3	6.1	6.7	6.3	7.0	7.4	7.2	7.6	8.9
Japan	39.8	30.9	47.2	34.4	41.1	50.2	44.6	45.8	42.5	54.1	49.8	49.8
Germany[1]	86.6	105.0	95.9	120.3	98.6	74.7	72.0	90.1	96.4	93.5	95.8	97.9
France	11.1	9.6	10.2	8.7	7.7	10.1	11.5	22.1	25.4	26.7	31.6	32.6
United Kingdom	16.0	19.3	21.3	25.9	27.3	20.4	8.8	20.9	18.5	15.2	17.3	19.0
Italy	33.4	28.5	33.8	46.6	39.1	40.2	34.7	37.3	46.7	59.1	57.4	58.5
Scientific instruments (ISIC 385)												
United States	13.7	11.9	13.0	14.9	16.1	18.5	18.7	18.7	18.7	18.4	18.3	18.6
Japan	18.3	19.9	23.3	27.3	27.6	37.2	43.9	48.9	60.2	60.9	54.5	58.2
Germany[1]	70.4	80.4	89.6	101.6	103.7	104.7	105.4	101.2	107.5	109.2	104.6	103.8
France	90.4	88.3	92.7	96.7	85.9	81.8	84.6	84.7	91.8	96.0	95.9	98.9
United Kingdom	93.5	90.8	106.6	116.9	123.7	144.8	140.2	135.6	146.8	157.9	158.4	169.4
Italy	40.9	43.1	46.5	50.8	60.5	70.1	76.3	109.4	117.4	122.6	119.8	120.7

ISIC = International Standard Industrial Classification

NOTE: Apparent market consumption is estimated as production minus exports plus imports.

[1] German data are for the former West Germany only.

SOURCE: Calculated from data in appendix table 6-4.

See figures 6–11 and 6–12.

Science & Engineering Indicators – 1993

Appendix table 6–6.

U.S. receipts and payments of royalties and fees associated with affiliated and unaffiliated foreign residents: 1987–91

	Foreign residents		
	Total	Affiliated	Unaffiliated
	Millions of dollars		
Receipts			
1987	9,914	7,629	2,285
1988	11,802	9,156	2,646
1989	13,064	10,207	2,857
1990	16,470	13,081	3,389
1991	17,799	14,014	3,785
Payments			
1987	1,844	1,296	547
1988	2,585	1,410	1,175
1989	2,602	1,778	824
1990	3,133	2,196	937
1991	3,984	2,857	1,127
Balance			
1987	8,070	6,333	1,738
1988	9,217	7,746	1,471
1989	10,462	8,429	2,033
1990	13,337	10,885	2,452
1991	13,815	11,157	2,658

SOURCE: Bureau of Economic Analysis, *Survey of Current Business*, Vol. 72, No. 9 (Sept. 1992).

See figure 6–13.

Science & Engineering Indicators – 1993

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Appendix table 6–7.

U.S. receipts and payments of royalties and license fees generated from the exchange and use of industrial processes with unaffiliated foreign residents, by region/country: 1987–91

	Receipts					Payments					Balance				
Region/country	1987	1988	1989	1990	1991	1987	1988	1989	1990	1991	1987	1988	1989	1990	1991
	Millions of U.S. dollars														
All countries	1,678	1,962	2,051	2,452	2,586	459	525	612	715	881	1,219	1,437	1,439	1,737	1,705
Canada	87	60	62	79	67	9	11	8	16	11	78	49	54	63	56
Europe	446	517	530	630	569	320	355	433	484	657	126	162	97	146	–88
European Community	353	410	378	501	476	248	279	342	362	448	105	131	36	139	28
France	73	82	52	78	96	33	37	51	54	70	40	45	1	24	26
Germany[1]	79	73	77	107	98	100	112	137	133	192	–21	–39	–60	–26	–94
Italy	57	73	68	105	71	25	20	22	29	38	32	53	46	76	33
United Kingdom	60	67	81	92	106	72	90	102	111	104	–12	–23	–21	–19	2
All other	93	107	152	129	93	72	76	91	122	209	21	31	61	7	–116
South and Central America	64	48	54	58	80	5	*	*	*	1	59	48	54	58	79
Brazil	19	7	14	8	8	*	*	*	*	*	19	7	14	8	8
Mexico	14	13	18	23	27	3	*	*	*	*	11	13	18	23	27
All other	31	28	22	27	45	2	NA	NA	NA	1	29	28	22	27	44
Africa	D	22	24	21	35	*	4	*	0	*	0	18	24	21	35
Middle East	D	18	17	22	25	2	3	4	3	4	-2	15	13	19	21
Asia and the Pacific	936	1,185	1,248	1,466	1,664	95	112	120	162	150	841	1,073	1,128	1,304	1,514
Hong Kong	4	6	7	6	6	1	*	*	0	*	3	6	7	6	6
India	18	40	26	21	14	*	*	*	*	*	18	40	26	21	14
Indonesia	5	5	8	11	20	0	*	0	0	0	5	5	8	11	20
Japan	723	883	897	1,028	1,244	88	108	109	142	148	635	775	788	886	1,096
Malaysia	*	*	2	2	2	0	0	0	0	0		0	2	2	2
The Philippines	3	4	4	4	2	0	*	1	0	0	3	4	3	4	2
Singapore	30	13	8	19	21	*	0	0	0	*	30	13	8	19	21
South Korea	34	107	167	249	228	*	*	D	D	*	34	107	167	249	228
Taiwan	21	46	34	56	57	*	*	D	1	*	21	46	34	55	57
All other	98	81	95	70	70	6	4	10	19	2	92	77	85	51	68
All other	145	112	116	176	146	28	40	47	50	58	117	72	69	126	88

* = less than $500,000; D = withheld to avoid disclosing operations of individual companies; NA = not available

NOTE: Industrial processes include patents and other proprietary inventions and technology.

[1] German data prior to 1990 are for the former West Germany only. Beginning in 1990, these data are also for the former East Germany.

SOURCE: Bureau of Economic Analysis, *Survey of Current Business*, Vol. 72, No. 9 (Sept. 1992): pp. 95-99.

See figure 6–14.

Appendix table 6–8.

R&D performance by U.S. manufacturers: 1973–90

Industry	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Millions of dollars																	
Total manufacturing . .	20,535	22,119	23,471	26,151	28,867	32,075	36,686	42,690	49,904	56,178	61,931	69,895	77,525	80,377	84,311	89,776	93,326	95,864
High-tech industries[1]	13,346	14,274	15,192	16,799	18,262	20,232	23,101	27,142	32,437	37,478	41,935	48,711	55,030	54,588	58,991	62,982	64,985	66,319
Drugs & med. . . .	698	807	981	1,091	1,117	1,308	1,517	1,777	2,084	2,499	2,927	3,318	3,488	3,658	4,100	4,746	5,210	5,532
Office & comp. eq.	1,733	2,103	2,220	2,402	2,655	2,883	3,214	3,962	4,443	5,675	6,655	8,156	9,866	9,797	9,363	10,668	11,590	12,230
Elect. machines[2].	1,834	2,047	2,121	2,382	2,295	2,476	2,775	3,049	3,201	3,092	2,737	2,365	1,987	1,614	1,239	1,200	1,291	1,321
Radio, TV, & comm. equip. . .	3,068	2,964	2,984	3,254	3,591	4,031	5,049	6,127	7,127	7,831	9,944	11,414	12,445	13,366	14,609	15,042	15,477	15,837
Aircraft.	5,052	5,278	5,713	6,339	7,033	7,536	8,041	9,198	11,968	14,451	15,406	18,858	22,231	21,050	24,458	25,900	25,654	25,388
Sci. instruments .	961	1,075	1,173	1,331	1,571	1,998	2,505	3,029	3,614	3,930	4,266	4,601	5,013	5,103	5,222	5,426	5,763	6,011
Chemicals[3]	1,418	1,643	1,766	1,925	2,085	2,272	2,521	2,858	3,542	4,079	4,220	4,580	4,960	5,185	5,435	6,026	6,327	6,524
Motor vehicles . . .	2,405	2,389	2,340	2,778	3,358	3,879	4,509	4,955	4,806	4,797	5,318	6,057	6,984	9,795	9,332	9,959	10,704	11,422
Other mfg	3,366	3,813	4,173	4,649	5,162	5,692	6,555	7,735	9,119	9,824	10,458	10,547	10,551	10,809	10,553	10,809	11,310	11,599
	Millions of constant 1985 dollars																	
Total manufacturing . .	46,937	46,504	45,034	47,202	48,749	50,214	52,873	56,206	59,708	63,284	67,045	72,506	77,525	78,303	79,590	81,567	81,198	79,943
High-tech industries[1]	30,505	30,010	29,149	30,322	30,840	31,673	33,294	35,735	38,809	42,218	45,398	50,531	55,030	53,180	55,688	57,223	56,540	55,305
Drugs & med. . . .	1,595	1,697	1,882	1,969	1,886	2,048	2,186	2,340	2,493	2,815	3,169	3,442	3,488	3,564	3,870	4,312	4,533	4,613
Office & com. eq. .	3,961	4,421	4,260	4,336	4,484	4,513	4,632	5,216	5,316	6,393	7,205	8,461	9,866	9,544	8,839	9,693	10,084	10,199
Elect. machines[2].	4,192	4,304	4,070	4,299	3,876	3,876	3,999	4,014	3,830	3,483	2,963	2,453	1,987	1,572	1,170	1,090	1,123	1,102
Radio, TV, & comm. equip. . .	7,013	6,232	5,725	5,873	6,064	6,311	7,277	8,067	8,527	8,822	10,765	11,840	12,445	13,022	13,791	13,667	13,466	13,207
Aircraft.	11,547	11,097	10,962	11,442	11,877	11,798	11,589	12,110	14,319	16,279	16,678	19,563	22,231	20,507	23,088	23,532	22,320	21,172
Sci. instruments .	2,197	2,260	2,251	2,402	2,653	3,128	3,610	3,988	4,324	4,427	4,618	4,773	5,013	4,971	4,930	4,930	5,014	5,013
Chemicals[3]	3,241	3,454	3,388	3,475	3,521	3,557	3,633	3,763	4,238	4,595	4,568	4,751	4,960	5,051	5,131	5,475	5,505	5,441
Motor vehicles . . .	5,497	5,023	4,490	5,014	5,671	6,073	6,498	6,524	5,750	5,404	5,757	6,283	6,984	9,542	8,809	9,048	9,313	9,525
Other mfg.	7,694	8,017	8,007	8,391	8,717	8,911	9,447	10,184	10,910	11,067	11,321	10,941	10,551	10,530	9,962	9,821	9,840	9,673

[1] The Organisation for Economic Co-operation and Development's standard definition of high-technology industries identifies six industries with high R&D intensities (ratio of R&D performed by industry to the value of gross output). This definition was established in 1986 using 1980 data. OECD reviewed the R&D intensities using preliminary 1989 data which reconfirmed the industries selected in 1986.

[2] Excluding communication equipment.

[3] Excluding drugs and medicines.

SOURCE: Organisation for Economic Co-operation and Development, Structural Analysis Database for Industrial Analysis, Analytical Business Enterprise R&D (STAN/ANBERD) file (Paris: 1993)

See figure 6–16.

Appendix table 6–9.

R&D performance by Japanese manufacturers: 1973–90

Industry	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Billions of yen																		
Total manufacturing	1,239	1,518	1,595	1,782	1,992	2,172	2,526	2,983	3,467	3,872	4,365	4,917	5,722	5,897	6,268	6,955	7,935	8,901
High-tech industries[1]	493	581	605	706	766	877	1,053	1,217	1,469	1,694	2,015	2,259	2,698	2,719	2,967	3,351	3,818	4,273
Drugs & med.	64	79	95	110	121	135	177	190	218	240	290	295	342	342	381	416	456	516
Office & com. eq.	39	31	44	54	67	77	94	112	138	163	203	303	346	374	466	599	808	895
Elect. machines[2]	147	160	167	206	229	267	312	281	342	386	458	538	616	619	666	742	866	996
Radio, TV, & comm. equip.	197	258	242	286	272	309	369	512	619	744	861	932	1,154	1,130	1,191	1,307	1,360	1,451
Aircraft	15	18	21	8	19	20	25	23	24	27	44	23	38	54	59	49	62	80
Sci. instruments	31	35	36	43	57	69	77	99	127	134	159	167	202	199	204	239	266	336
Chemicals[3]	174	225	227	242	265	269	313	368	399	448	485	558	594	642	715	774	858	901
Motor vehicles	153	181	192	213	261	322	360	402	500	543	587	664	764	806	790	915	1,072	1,281
Other mfg	419	531	572	621	700	704	800	995	1,099	1,187	1,278	1,437	1,666	1,730	1,795	1,915	2,187	2,446
1985 purchasing power parities																		
Total manufacturing	4,769	5,309	5,704	6,286	7,046	7,851	9,682	11,932	14,639	17,116	19,673	22,437	26,408	27,317	29,900	34,150	39,711	45,506
High-tech industries[1]	1,897	2,031	2,163	2,490	2,708	3,169	4,035	4,869	6,202	7,487	9,081	10,307	12,450	12,594	14,153	16,455	19,109	21,847
Drugs & med.	248	277	340	386	426	487	678	759	922	1,060	1,307	1,348	1,578	1,584	1,816	2,044	2,282	2,639
Office & comp. eq.	149	110	157	189	238	279	360	448	582	721	914	1,380	1,595	1,731	2,222	2,940	4,044	4,575
Elect. machines[2]	566	558	596	728	810	965	1,194	1,125	1,444	1,705	2,062	2,456	2,844	2,869	3,176	3,643	4,336	5,092
Radio, TV, & comm. equip.	760	903	867	1,007	964	1,115	1,413	2,049	2,615	3,287	3,882	4,255	5,326	5,235	5,682	6,418	6,806	7,418
Aircraft	56	62	75	27	67	73	94	91	103	121	201	105	177	252	283	239	309	406
Sci. instruments	119	121	128	152	202	250	296	397	535	593	716	764	931	923	974	1,172	1,332	1,717
Chemicals[3]	669	787	812	855	939	974	1,199	1,474	1,684	1,979	2,184	2,544	2,744	2,972	3,412	3,801	4,294	4,605
Motor vehicles	591	634	685	752	924	1,163	1,380	1,608	2,110	2,401	2,647	3,030	3,527	3,736	3,771	4,493	5,365	6,549
Other mfg	1,613	1,857	2,044	2,189	2,475	2,545	3,067	3,981	4,643	5,249	5,761	6,556	7,688	8,015	8,565	9,401	10,944	12,505
Billions of constant 1985 yen																		
Total manufacturing	2,307	2,354	2,295	2,380	2,496	2,592	2,937	3,315	3,716	4,080	4,533	4,997	5,722	5,792	6,157	6,805	7,630	8,373
High-tech ind.[1]	918	901	870	943	959	1,046	1,224	1,353	1,574	1,785	2,092	2,295	2,698	2,670	2,914	3,279	3,671	4,020
Drugs & med.	120	123	137	146	151	161	206	211	234	253	301	300	342	336	374	407	438	486
Office & comp. eq.	72	49	63	72	84	92	109	125	148	172	210	307	346	367	458	586	777	842
Elect. machines[2]	274	247	240	276	287	319	362	312	366	407	475	547	616	608	654	726	833	937
Radio, TV, & comm. equip.	367	400	349	381	341	368	428	569	664	783	894	947	1,154	1,110	1,170	1,279	1,308	1,365
Aircraft	27	28	30	10	24	24	29	25	26	29	46	23	38	53	58	48	59	75
Sci. instruments	57	54	52	58	72	83	90	110	136	141	165	170	202	196	201	234	256	316
Chemicals[3]	324	349	326	324	333	322	364	409	428	472	503	567	594	630	703	757	825	847
Motor vehicles	286	281	276	285	327	384	419	447	536	572	610	675	764	792	776	895	1,031	1,205
Other mfg	780	823	822	829	877	840	930	1,106	1,178	1,251	1,327	1,460	1,666	1,700	1,764	1,873	2,103	2,301

[1] The Organisation for Economic Co-operation and Development's standard definition of high-technology industries identifies six industries with high R&D intensities (ratio of R&D performed by industry to the value of gross output). This definition was established in 1986 using 1980 data. OECD reviewed the R&D intensities using preliminary 1989 data which reconfirmed the industries selected in 1986.

[2] Excludes communication equipment.

[3] Excludes drugs and medicines.

SOURCE: Organisation for Economic Co-operation and Development, Structural Analysis Database for Industrial Analysis, Analytical Business Enterprise R&D file (STAN/ANBERD) (Paris: 1993).

See figure 6–17.

Appendix table 6–10.
R&D performance by German manufacturers: 1973–90

Industry	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Millions of deutsche marks																	
Total manufacturing	10,796	11,928	13,228	14,314	15,421	18,382	21,113	22,939	24,352	26,586	27,951	29,700	33,974	36,275	39,232	41,610	44,252	46,748
High-tech industries[1]	5,311	5,918	6,634	7,017	7,383	8,684	9,602	10,017	10,273	10,980	11,527	12,482	14,677	16,125	17,996	19,232	20,647	21,893
Drugs & med.	692	782	911	986	1,063	1,350	1,460	1,353	1,257	1,445	1,580	1,491	1,534	1,733	2,172	2,345	2,531	2,702
Office & comp. eq.	177	197	239	349	454	488	526	566	618	709	768	802	916	1,035	1,225	1,358	1,505	1,697
Elect. machines[2]	1,367	1,516	1,676	1,737	1,804	2,153	2,384	2,495	2,533	2,613	2,646	2,826	3,309	3,612	4,002	3,903	3,807	3,834
Radio, TV, & comm. equip.	1,759	2,016	2,274	2,427	2,580	3,096	3,446	3,606	3,741	4,114	4,460	4,941	5,918	6,626	7,526	7,982	8,466	8,743
Aircraft	1,084	1,151	1,254	1,240	1,202	1,247	1,352	1,511	1,616	1,583	1,576	1,920	2,439	2,523	2,419	2,956	3,612	4,146
Sci. instruments	232	256	280	278	280	350	434	486	508	516	497	502	561	596	652	688	726	771
Chemicals[3]	2,183	2,522	2,870	3,171	3,348	3,409	3,534	4,073	4,598	4,880	4,906	5,214	5,981	6,243	6,491	6,863	7,257	7,646
Motor vehicles	1,344	1,413	1,531	1,739	1,981	2,439	2,923	3,281	3,616	4,138	4,482	4,742	5,383	5,808	6,400	6,896	7,431	7,973
Other mfg	1,958	2,075	2,193	2,387	2,710	3,850	5,054	5,567	5,865	6,589	7,036	7,262	7,933	8,099	8,345	8,619	8,917	9,236
Total manufacturing	3,660	4,127	4,741	5,263	5,841	7,180	8,617	9,761	10,363	12,140	12,705	13,750	15,802	16,640	18,163	19,627	21,173	22,475
	1985 purchasing power parities																	
High-tech industries[1]	1,800	2,048	2,378	2,580	2,796	3,392	3,919	4,262	4,372	5,014	5,240	5,779	6,827	7,397	8,331	9,072	9,879	10,526
Drugs & med.	235	270	327	363	403	527	596	576	535	660	718	690	713	795	1,006	1,106	1,211	1,299
Office & comp. eq.	60	68	86	128	172	191	215	241	263	324	349	371	426	475	567	640	720	816
Elect. machines[2]	463	525	601	638	683	841	973	1,062	1,078	1,193	1,203	1,308	1,539	1,657	1,853	1,841	1,822	1,843
Radio, TV, & comm. equip.	596	698	815	892	977	1,209	1,407	1,534	1,592	1,879	2,027	2,288	2,753	3,039	3,484	3,765	4,051	4,203
Aircraft	367	398	449	456	455	487	552	643	688	723	716	889	1,134	1,157	1,120	1,394	1,728	1,993
Sci. instruments	79	89	100	102	106	137	177	207	216	235	226	232	261	273	302	325	347	371
Chemicals[3]	740	873	1,029	1,166	1,268	1,332	1,442	1,733	1,957	2,228	2,230	2,414	2,782	2,864	3,005	3,237	3,472	3,676
Motor vehicles	456	489	549	639	750	953	1,193	1,396	1,539	1,889	2,037	2,195	2,504	2,664	2,963	3,253	3,556	3,833
Other mfg	664	718	786	878	1,027	1,504	2,063	2,369	2,496	3,008	3,198	3,362	3,690	3,715	3,863	4,065	4,267	4,440
	Millions of constant 1985 deutsche marks																	
Total manufacturing	19,917	20,618	21,580	22,497	23,417	26,680	29,516	30,554	31,174	32,638	33,079	34,325	38,455	39,782	42,181	44,066	45,449	46,748
High-tech industries[1]	9,798	10,229	10,823	11,028	11,210	12,605	13,424	13,342	13,151	13,479	13,642	14,426	16,613	17,684	19,349	20,367	21,206	21,893
Drugs & med.	1,277	1,351	1,486	1,550	1,614	1,959	2,041	1,802	1,609	1,774	1,870	1,723	1,736	1,901	2,335	2,483	2,599	2,702
Office & comp. eq.	327	341	390	548	689	708	735	754	791	870	909	927	1,037	1,135	1,317	1,438	1,546	1,697
Elect. machines[2]	2,522	2,620	2,734	2,729	2,739	3,125	3,333	3,323	3,243	3,208	3,131	3,266	3,745	3,961	4,303	4,134	3,910	3,834
Radio, TV, & comm. equip.	3,245	3,485	3,710	3,814	3,918	4,494	4,818	4,803	4,789	5,050	5,278	5,711	6,698	7,267	8,092	8,453	8,695	8,743
Aircraft	2,000	1,990	2,046	1,949	1,825	1,810	1,890	2,013	2,069	1,943	1,865	2,219	2,761	2,767	2,601	3,130	3,710	4,146
Sci. instruments	428	443	457	438	425	508	607	647	650	633	588	580	635	654	701	729	746	771
Chemicals[3]	4,027	4,359	4,682	4,984	5,084	4,948	4,941	5,425	5,886	5,991	5,806	6,026	6,770	6,846	6,979	7,268	7,453	7,646
Motor vehicles	2,479	2,443	2,497	2,733	3,007	3,540	4,086	4,371	4,629	5,080	5,304	5,481	6,093	6,369	6,881	7,303	7,632	7,973
Other mfg	3,612	3,586	3,578	3,751	4,115	5,588	7,065	7,415	7,508	8,088	8,327	8,393	8,979	8,882	8,972	9,127	9,158	9,236

NOTE: German data are for the former West Germany only.

[1] The Organisation for Economic Co-operation and Development's standard definition of high-technology industries identifies six industries with high R&D intensities (ratio of R&D performed by industry to the value of gross output). This definition was established in 1986 using 1980 data. OECD reviewed the R&D intensities using preliminary 1989 data which reconfirmed the industries selected in 1986.

[2] Excludes communication equipment.

[3] Excludes drugs and medicines.

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SOURCE: Organisation for Economic Co-operation and Development, Structural Analysis (Database for Industrial Analysis, Analytical Business Enterprise R&D file (STAN/ANBERD) (Paris: 1993).

See figure 6–18.

Appendix table 6–11.

R&D performance by European Community manufacturers: 1973–90

Industry	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
	Millions of European currency units																	
Total manufacturing . .	11,069	12,430	13,794	15,291	16,816	19,358	23,127	26,074	29,363	31,964	33,978	37,716	41,732	44,665	48,022	51,805	56,126	60,565
High-tech industries[1]	4,618	5,174	5,789	6,509	7,293	8,620	10,344	11,689	13,078	14,346	15,506	17,404	19,412	21,278	22,876	24,623	26,257	28,139
Drugs & med. . . .	362	400	467	592	733	816	931	995	1,146	1,302	1,433	1,725	2,017	2,129	2,304	2,571	2,866	2,984
Office & comp. eq.	949	1,107	1,221	1,333	1,394	1,576	1,789	1,973	2,181	2,379	2,494	2,889	3,449	3,800	4,130	4,163	4,032	4,113
Elec. machines[2] .	1,787	2,051	2,345	2,612	2,928	3,634	4,519	5,239	5,906	6,420	6,963	7,610	8,287	9,248	9,874	10,575	11,266	12,165
Radio, TV, & comm. equip. . .	1,262	1,342	1,457	1,631	1,858	2,151	2,596	2,907	3,246	3,612	3,992	4,519	4,932	5,235	5,654	6,310	7,024	7,846
Aircraft.	207	218	235	246	260	312	385	438	488	512	500	544	612	715	730	810	847	832
Sci. instruments .	51	56	63	94	121	132	125	137	111	121	125	118	115	151	184	194	221	200
Chemicals[3]	746	848	985	1,111	1,237	1,502	1,784	1,921	2,168	2,479	2,723	2,911	3,165	3,435	4,139	4,714	5,309	6,039
Motor vehicles . . .	1,751	1,872	1,955	2,121	2,166	2,342	2,877	3,338	3,755	3,903	3,972	4,480	5,100	5,290	5,456	5,881	6,815	7,609
Other mfg	3,954	4,536	5,067	5,550	6,120	6,893	8,121	9,126	10,362	11,236	11,778	12,920	14,055	14,663	15,551	16,587	17,745	18,778

SOURCE: Organisation for Economic Co-operation and Development, Structural Analysis Database for Industrial Analysis, Analytical Business Enterprise R&D file (STAN/ANBERD) (Paris: 1993).

[1] The Organisation for Economic Co-operation and Development's standard definition of high-technology industries identifies six industries with high R&D intensities (ratio of R&D performed by industry to the value of gross output). This definition was established in 1986 using 1980 data. OECD reviewed the R&D intensities using preliminary 1989 data which reconfirmed the industries selected in 1986.

[2] Excludes communication equipment.

[3] Excludes drugs and medicines.

Science & Engineering Indicators – 1993

Appendix table 6–12.

U.S. patents granted, by inventor sector, inventor residence, and year of grant: 1963–91

Inventor sector/residence	Total	1963–77	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Total	1,999,276	990,192	66,097	48,849	61,810	65,766	57,881	56,855	67,189	71,649	70,790	82,863	77,809	95,321	90,158	96,047
U.S. origin, total	1,278,577	715,804	41,250	30,076	37,351	39,221	33,891	32,867	38,358	39,550	38,088	43,465	40,415	50,063	47,283	50,895
U.S. corporation-owned	918,740	516,488	29,420	21,145	25,965	27,621	24,081	24,040	28,005	28,946	27,319	31,274	29,269	35,734	33,359	36,074
U.S. government-owned	39,389	24,744	1,231	960	1,231	1,115	1,003	1,041	1,224	1,124	1,008	969	725	868	972	1,174
U.S. individual-owned	313,444	171,831	10,398	7,802	9,938	10,241	8,538	7,558	8,881	9,244	9,454	10,854	10,066	12,996	12,499	13,144
Foreign-owned	7,004	2,741	201	169	217	244	269	228	248	236	307	368	355	465	453	503
Foreign origin, total	720,699	274,388	24,847	18,773	24,459	26,545	23,990	23,988	28,831	32,099	32,702	39,398	37,394	45,258	42,875	45,152
U.S.-owned	56,602	26,976	1,961	1,364	1,694	1,839	1,715	1,658	2,028	2,266	2,165	2,441	2,145	2,850	2,679	2,821
Foreign-owned	664,097	247,412	22,886	17,409	22,765	24,706	22,275	22,330	26,803	29,833	30,537	36,957	35,249	42,408	40,196	42,331
Foreign corporation	549,614	193,052	18,874	14,445	18,662	20,546	18,588	19,020	22,989	25,718	26,226	31,978	30,588	36,968	35,013	36,947
Foreign government	8,131	2,768	249	186	253	249	368	336	437	481	477	551	451	440	418	467
Foreign individual	106,352	51,592	3,763	2,778	3,850	3,911	3,319	2,974	3,377	3,634	3,834	4,428	4,210	5,000	4,765	4,917
Country																
Argentina	590	328	21	24	18	25	18	21	20	11	17	18	16	20	17	16
Australia	7,286	2,503	281	211	265	319	266	237	292	340	373	389	416	501	431	462
Austria	7,332	3,034	274	222	267	279	228	267	256	318	357	344	337	397	393	359
Belgium	7,195	3,497	264	185	244	263	224	205	240	240	242	294	302	358	313	324
Brazil	653	240	24	19	24	23	27	19	20	30	27	34	29	36	41	60
Canada	34,971	15,898	1,226	862	1,081	1,135	990	1,000	1,206	1,340	1,311	1,593	1,488	1,957	1,854	2,030
Czechoslovakia	2,021	1,395	91	50	55	41	50	38	33	54	35	46	33	34	39	27
Denmark	4,226	1,957	168	105	157	130	121	125	150	187	182	204	151	221	158	210
Finland	3,515	866	125	77	121	140	125	116	167	200	210	275	232	230	303	328
France	60,537	27,204	2,118	1,604	2,088	2,181	1,975	1,895	2,162	2,399	2,366	2,868	2,658	3,136	2,860	3,023
Germany[1]	161,089	68,936	5,874	4,546	5,780	6,302	5,467	5,477	6,322	6,717	6,850	7,881	7,349	8,341	7,590	7,657
Hong Kong	576	148	21	13	27	33	18	14	24	25	30	34	41	47	52	49
Hungary	1,994	585	66	63	87	98	112	106	111	108	131	127	94	129	92	85
India	374	193	14	14	4	6	4	14	12	10	18	12	14	14	23	22
Ireland	652	203	21	10	17	17	24	18	29	30	28	38	43	65	54	55
Israel	3,480	898	99	84	113	123	114	109	162	179	188	245	237	325	299	305
Italy	22,041	8,935	725	596	805	883	752	625	794	919	995	1,183	1,075	1,293	1,258	1,203
Japan	224,551	49,700	6,912	5,250	7,124	8,387	8,149	8,792	11,109	12,743	13,198	16,538	16,140	20,116	19,477	20,916
Luxembourg	467	121	16	21	13	27	26	27	24	37	31	22	29	29	17	27
Mexico	1,444	930	24	36	41	43	35	32	42	32	37	49	44	39	32	28
The Netherlands	19,275	8,610	659	525	654	641	618	626	726	766	721	921	805	1,060	956	987
New Zealand	942	290	41	23	51	47	44	38	50	33	52	68	54	58	52	41
Norway	2,407	1,074	89	80	79	93	65	66	87	90	81	135	121	125	112	110
Poland	595	312	33	29	37	38	26	20	15	11	14	13	8	14	17	8
South Africa	2,201	907	81	64	74	111	73	61	82	96	88	107	102	135	115	105
South Korea	1,221	59	12	5	8	17	14	26	30	39	45	84	97	159	225	401
Spain	2,215	954	92	49	65	58	49	50	69	78	97	115	126	131	129	153
Sweden	21,136	10,361	826	573	822	766	685	623	701	857	883	948	776	834	767	714
Switzerland	33,969	16,734	1,330	1,025	1,265	1,239	1,147	1,017	1,174	1,233	1,209	1,373	1,245	1,361	1,284	1,333
Taiwan	3,970	104	29	38	65	80	88	65	98	174	208	343	457	592	731	898
United Kingdom	76,338	41,558	2,722	1,909	2,406	2,475	2,134	1,931	2,271	2,495	2,408	2,777	2,581	3,093	2,783	2,795
USSR	6,759	3,522	412	354	460	373	209	222	214	147	116	121	96	161	174	178

[1] German data are for the former West Germany only.

SOURCE: Patent and Trademark Office, *Patenting Trends in the United States, 1963-91* (Washington, DC: Sept. 1992).

See figures 6–19 and 6–20.

Appendix table 6–13.

Patent classes most emphasized by inventors from the United States patenting in the United States: 1981 and 1991

		Activity index	
Patent class	Class number	1981	1991
Mineral oils: Processes and products	208	1.813	1.977
Chemistry, hydrocarbons	585	1.786	1.938
Wells	166	1.747	1.777
Chemistry—Analytical and immunological testing	436	1.340	1.523
Food or edible material: Processes, compositions and products	426	1.146	1.438
Superconductor technology—Apparatus, material, process	505	0.000	1.434
Error detection/correction and fault detection/recovery	371	1.395	1.432
Amplifiers	330	1.017	1.415
Chemistry—Molecular biology and microbiology	435	1.107	1.402
Drug, bio-affecting and body treating compositions	424	1.092	1.386
Chemistry, lignins or reaction products thereof	530	1.225	1.373
Part of the class 520 series—synthetic resins or natural rubber	521	1.114	1.371
Compositions	252	1.356	1.359
Electrical transmission or interconnection systems	307	1.216	1.359
Electricity, conductors and insulators	174	1.216	1.348
Induced nuclear reaction, systems and elements	376	0.787	1.344
Electrical connectors	439	1.572	1.334
Information processing system organization	395	1.594	1.333
Catalyst, solid sorbent, or support therefore, product	502	1.593	1.331
Electricity, electrical systems and devices	361	1.215	1.323
Valves and valve actuation	251	1.207	1.317
Electricity, measuring and testing	324	1.095	1.311
Gas separation	55	1.078	1.311
Pulse or digital communications	375	1.222	1.308
Multiplex communications	370	1.084	1.304
Communication, electrical: Acoustic wave systems and devices	367	1.236	1.296
Classification undetermined	1	0.944	1.289
Envelopes, wrappers & paperboard boxes	229	1.638	1.280
Process disinfecting, deodorizing, preserving or sterilizing	422	1.041	1.277
Semiconductor device manufacturing process	437	1.425	1.264
Part of the class 520 series—synthetic resins or natural rubber	525	1.341	1.262
Telecommunications	455	0.989	1.259
Part of the class 520 series—synthetic resins or natural rubber	526	1.202	1.257
Surgery	604	1.095	1.253
Optical waveguides	385	1.016	1.252
Surgery	606	0.631	1.251
Compositions & Ceramic	501	0.967	1.247
Part of the class 520 series—synthetic resins or natural rubber	523	1.310	1.242
Part of the class 532-570 series—organic compounds	556	1.391	1.234
Coded data generation or conversion	341	1.365	1.230
Heat exchange	165	1.074	1.217
Part of the class 532-570 series—organic compounds	564	1.541	1.217
Electrical computers and data processing systems	364	1.234	1.209
Wave transmission lines and networks	333	0.971	1.207
Coating processes	427	1.122	1.205
Communications, directive radio wave systems & devices	342	1.012	1.194
Fluid handling	137	1.024	1.192
Part of the class 520 series—synthetic resins or natural rubber	524	1.339	1.191
Electric power conversion systems	363	1.187	1.190
Cleaning and liquid contact with solids	134	1.102	1.177

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to Patent and Trademark Office classes that received at least 200 patents from all countries in 1991.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1991," report prepared for the National Science Foundation (Washington, DC: Sept. 1992).

See text table 6–1.

Appendix table 6–14.

Patent classes most emphasized by inventors from Japan patenting in the United States: 1981 and 1991

Patent class	Class number	Activity index	
		1981	1991
Dynamic information storage or retrieval	369	2.987	3.213
Photography	354	4.319	3.192
Photocopying	355	3.257	3.142
Dynamic magnetic information storage or retrieval	360	3.122	2.912
Typewriting machines	400	1.123	2.602
Radiation imagery chemistry—process, composition or products	430	3.171	2.533
Recorders	346	2.902	2.491
Pictorial communication; television	358	2.443	2.474
Static information storage and retrieval	365	1.657	2.432
Active solid state devices, e.g., transistors, solid state diodes	357	2.103	2.202
Sewing	112	1.813	2.196
Music	84	1.631	2.127
Motor vehicles	186	1.073	2.124
Internal-combustion engines	123	2.577	2.065
Image analysis	382	1.323	2.060
Machine elements and mechanisms	74	1.525	2.032
Electricity, motive power systems	318	1.509	1.965
Metal treatment	148	2.075	1.913
Registers	235	0.813	1.845
Coating apparatus	118	1.544	1.797
Optics, systems (including communication) and elements	359	2.442	1.785
Electrical generator or motor structure	310	1.374	1.753
Clutches and power-stop control	192	1.351	1.731
Sheet feeding or delivering	271	1.587	1.719
Information processing system organization	395	1.228	1.713
Electrical audio signal processing and systems	381	1.954	1.623
Electrical computers and data processing systems	364	1.575	1.547
Radiant energy	250	1.187	1.535
Semiconductor device manufacturing process	437	1.549	1.528
Stock material or miscellaneous articles	428	1.268	1.507
Chemistry, electrical current producing apparatus, pro	429	0.620	1.379
Coherent light generators	372	0.795	1.354
Compositions & Ceramic	501	2.129	1.336
Error detection/correction and fault detection/recovery	371	0.857	1.322
Part of the class 520 series—synthetic resins or natural rubber	526	1.538	1.320
Coded data generation or conversion	341	1.068	1.310
Electrical transmission or interconnection systems	307	1.638	1.298
Electricity, circuit makers and breakers	200	1.311	1.246
Part of the class 520 series—synthetic resins or natural rubber	525	1.549	1.237
Telecommunications	455	2.325	1.237
Multiplex communications	370	0.683	1.222
Glass manufacturing	65	0.779	1.187
Part of the class 520 series—synthetic resins or natural rubber	523	1.383	1.181
Part of the class 520 series—synthetic resins or natural rubber	524	1.265	1.177
Winding and reeling	242	1.387	1.165
Coating processes	427	1.156	1.147
Superconductor technology: Apparatus, material, process	505	0.000	1.141
Metallurgy	75	1.516	1.140
Electric heating	219	1.422	1.138
Telephonic communications	379	0.660	1.137

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to Patent and Trademark Office classes that received at least 200 patents from all countries in 1991.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1991," report prepared for the National Science Foundation (Washington, DC: Sept. 1992).

See text table 6–1.

Appendix table 6–15.

Patent classes most emphasized by inventors from Germany patenting in the United States: 1981 and 1991

Patent class	Class number	Activity index 1981	Activity index 1991
Printing	101	1.275	4.684
Chemistry, fertilizers	71	1.616	3.620
Part of the class 532-570 series—organic compounds	568	1.799	3.058
Part of the class 532-570 series—organic compounds	548	2.277	2.524
Part of the class 532-570 series—organic compounds	560	1.624	2.419
Ammunition and explosives	102	1.679	2.401
Bearing or guides	384	1.679	2.213
Winding and reeling	242	1.099	2.088
Brakes	188	1.587	1.949
Compositions, coating or plastic	106	1.390	1.874
Part of the class 520 series—synthetic resins or natural rubber	528	1.703	1.871
Internal-combustion engines	123	2.016	1.836
Typewriting machines	400	1.394	1.804
Chemistry, inorganic	423	1.329	1.796
Part of the class 520 series—synthetic resins or natural rubber	521	2.010	1.793
X-ray or gamma ray systems or devices	378	3.085	1.791
Plastic article or earthenware shaping or treating: ap	425	1.209	1.769
Metal deforming	72	1.151	1.749
Part of the class 520 series—synthetic resins or natural rubber	524	1.537	1.747
Part of the class 532-570 series—organic compounds	556	1.259	1.656
Part of the class 532-570 series—organic compounds	564	1.263	1.649
Part of the class 520 series—synthetic resins or natural rubber	525	1.056	1.618
Clutches and power-stop control	192	1.431	1.608
Power plants	60	0.763	1.569
Chemistry, electrical and wave energy	204	1.030	1.548
Sheet feeding or delivering	271	2.315	1.528
Solid material comminution or disintegration	241	0.805	1.507
Metal founding	164	0.720	1.503
Part of the class 520 series—synthetic resins or natural rubber	523	1.176	1.480
Package making	53	1.255	1.469
Conveyers, power-driven	198	1.453	1.464
Land vehicles, bodies and tops	296	1.269	1.449
Drug, bio-affecting and body treating compositions	514	1.655	1.423
Heat exchange	165	0.750	1.368
Part of the class 532-570 series—organic compounds	549	1.243	1.362
Electric power conversion systems	363	0.835	1.357
Pumps	417	1.132	1.331
Fluid sprinkling, spraying and diffusing	239	0.872	1.326
Joints and connections	403	1.061	1.312
Plastic and nonmetallic article shaping or treating: Process	264	1.094	1.280
Cutting	83	1.155	1.269
Optical waveguides	385	1.230	1.265
Machine elements and mechanisms	74	1.387	1.255
Sewing	112	1.865	1.245
Cutlery	30	0.532	1.239
Catalyst, solid sorbent, or support therefore, product	502	0.856	1.236
Measuring and testing	73	1.207	1.233
Part of the class 532-570 series—organic compounds	536	0.429	1.230
Electricity, circuit makers and breakers	200	1.003	1.228
Part of the class 520 series—synthetic resins or natural rubber	526	1.101	1.224

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to Patent and Trademark Office classes that received at least 200 patents from all countries in 1991. German data are for the former West Germany only.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1991," report prepared for the National Science Foundation (Washington, DC: Sept. 1992).

See text table 6–1.

Appendix table 6–16.

Patent classes most emphasized by inventors from Canada patenting in the United States: 1981 and 1991

Patent class	Class number	Activity index	
		1981	1991
Metallurgy	75	3.282	5.229
Chemistry, inorganic	423	2.491	3.452
Electricity, conductors and insulators	174	2.512	3.426
Plastic article or earthenware shaping or treating: ap	425	3.797	3.387
Multiplex communications	370	1.459	3.323
Chemistry: Analytical and immunological testing	436	0.417	2.853
Telephonic communications	379	5.820	2.809
Static structures, e.g., buildings	52	1.594	2.500
Supports	248	1.106	2.425
Mineral oils: Processes and products	208	3.218	2.402
Apparel	2	0.597	2.280
Wells	166	2.082	2.245
Chemistry, electrical current producing apparatus, product and process	429	0.000	2.224
Material or article handling	414	1.238	2.219
Cleaning and liquid contact with solids	134	0.938	2.173
Fluid sprinkling, spraying and diffusing	239	0.318	1.939
Solid material comminution or disintegration	241	2.698	1.917
Harvesters	56	1.683	1.908
Animal husbandry	119	0.000	1.844
Optical waveguides	385	4.007	1.727
Compositions: Ceramic	501	2.421	1.679
Chemistry, fertilizers	71	0.000	1.672
Adhesive bonding and miscellaneous chemical manufacture	156	1.050	1.657
Measuring and testing	73	1.334	1.643
Wave transmission lines and networks	333	1.191	1.620
Movable or removable closures	49	1.417	1.609
Electricity, circuit makers and breakers	200	0.000	1.596
Pipe joints or couplings	285	0.460	1.582
Sewing	112	0.000	1.533
Liquid purification or separation	210	2.157	1.519
Electric power conversion systems	363	2.913	1.512
Part of the class 520 series—synthetic resins or natural rubber	521	0.366	1.498
Chemistry: Molecular biology and microbiology	435	0.000	1.477
Plastic and nonmetallic article shaping or treating: Process	264	1.002	1.461
Electric heating	219	0.597	1.430
Heat exchange	165	1.712	1.412
Motor vehicles	180	0.970	1.404
Conveyers, power-driven	198	1.106	1.394
Locks	70	2.626	1.384
Amplifiers	330	0.566	1.355
Bearing or guides	384	0.000	1.328
Chemistry, electrical and wave energy	204	1.785	1.315
Refrigeration	62	0.877	1.271
Metal founding	164	1.005	1.256
Optics, measuring and testing	356	1.192	1.189
Metal working	29	0.733	1.180
Receptacles	220	2.060	1.161
Envelopes, wrappers and paperboard boxes	229	0.615	1.161
Dispensing	222	0.932	1.150
Coherent light generators	372	1.437	1.142

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to Patent and Trademark Office that received at least 200 patents from all countries in 1991.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1991," report prepared for the National Science Foundation (Washington, DC: Sept. 1992).

See text table 6–2.

Appendix table 6–17.

Patent classes most emphasized by inventors from France patenting in the United States: 1981 and 1991

		Activity index	
Patent class	Class number	1981	1991
Induced nuclear reaction, systems and elements	376	1.496	4.750
Wave transmission lines and networks	333	3.082	3.193
Brakes	188	1.274	2.934
Part of the class 532-570 series—organic compounds	564	1.053	2.910
Part of the class 532-570 series—organic compounds	560	0.804	2.725
Communications, directive radio wave systems & devices	342	1.916	2.702
X-ray or gamma ray systems or devices	378	0.774	2.647
Glass manufacturing	65	1.552	2.591
Pipe joints or couplings	285	1.871	2.525
Communication, electrical: Acoustic wave systems and devices	367	1.954	2.477
Part of the class 532-570 series—organic compounds	568	1.569	2.475
Chemistry, inorganic	423	1.300	2.465
Registers	235	2.173	2.302
Electricity, circuit makers and breakers	200	0.604	2.246
Aeronautics	244	1.609	2.092
Land vehicle	280	0.697	2.090
Movable or removable closures	49	0.524	2.076
Catalyst, solid sorbent, or support therefore, product	502	0.883	2.069
Part of the class 532-570 series—organic compounds	536	0.797	2.025
Pulse or digital communications	375	3.575	1.976
Drug, bio-affecting and body treating compositions	514	2.045	1.916
Metal founding	164	2.043	1.916
Chemistry, lignins or reaction products thereof	530	0.921	1.796
Harvesters	56	1.400	1.790
Mineral oils: Processes and products	208	0.357	1.690
Process disinfecting, deodorizing, preserving or sterilizing	422	0.653	1.606
Drug, bio-affecting and body treating compositions	424	1.666	1.598
Metal treatment	148	1.060	1.576
Electricity, electrical systems and devices	361	0.646	1.543
Electric lamp and discharge devices	313	0.503	1.496
Part of the class 520 series—synthetic resins or natural rubber	526	1.363	1.470
Multiplex communications	370	3.505	1.448
Amplifiers	330	1.255	1.431
Chairs and seats	297	1.273	1.430
Error detection/correction and fault detection/recovery	371	0.827	1.406
Prothesis (i.e., artificial body members), parts or aid	623	1.277	1.378
Part of the class 520 series—synthetic resins or natural rubber	528	1.106	1.363
Electricity, motive power systems	318	0.819	1.359
Electric lamp and discharge devices, systems	315	1.583	1.353
Coded data generation or conversion	341	1.427	1.312
Joints and connections	403	1.011	1.310
Clutches and power-stop control	192	0.359	1.304
Optics, measuring and testing	356	1.058	1.302
Adhesive bonding and miscellaneous chemical manufacture	156	0.949	1.296
Abrading	51	1.062	1.295
Electrical generator or motor structure	310	1.193	1.264
Power plants	60	1.221	1.262
Compositions	252	1.159	1.252
Package making	53	0.883	1.248
Part of the class 532-570 series—organic compounds	549	1.872	1.246

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to Patent and Trademark Office classes that received at least 200 patents from all countries in 1991.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1991," report prepared for the National Science Foundation (Washington, DC: Sept. 1992).

See text table 6–2.

Appendix table 6–18.

Patent classes most emphasized by inventors from Great Britain patenting in the United States: 1981 and 1991

Patent class	Class number	Activity index	
		1981	1991
Drug, bio-affecting and body treating compositions	514	2.899	2.988
Joints and connections	403	1.926	2.702
Chemistry, fertilizers	71	1.798	2.698
Metal fusion bonding	228	1.370	2.416
Optical waveguides	385	1.254	2.388
Aeronautics	244	0.511	2.158
Part of the class 532-570 series—organic compounds	548	1.302	2.042
Pulse or digital communications	375	1.376	2.038
Drug, bio-affecting and body treating compositions	424	2.302	2.007
Wells	166	0.559	1.976
Brakes	188	2.003	1.958
Conveyers, power-driven	198	2.193	1.928
Glass manufacturing	65	1.075	1.909
Compositions	252	1.839	1.901
Communications, directive radio wave systems & devices	342	1.390	1.900
Geometrical instruments	33	0.550	1.897
Pictorial communication; television	358	1.219	1.812
Pipe joints or couplings	285	1.296	1.685
Hydraulic and earth engineering	405	1.452	1.664
Catalyst, solid sorbent, or support therefore, product	502	1.047	1.622
Electric heating	219	1.121	1.616
Part of the class 532-570 series—organic compounds	549	0.969	1.607
Metallurgy	75	0.881	1.558
Chemistry, electrical current producing apparatus, product and process	429	0.868	1.538
Power plants	60	1.724	1.532
Sheet feeding or delivering	271	0.467	1.403
Measuring and testing	73	0.974	1.383
Compositions, coating or plastic	106	1.562	1.355
Pumps	417	2.283	1.353
Part of the class 520 series—synthetic resins or natural rubber	523	1.079	1.347
Metal deforming	72	1.372	1.341
Part of the class 532-570 series—organic compounds	556	1.376	1.340
Electric lamp and discharge devices, systems	315	1.340	1.309
Cutlery	30	0.558	1.286
Optics, measuring and testing	356	1.343	1.279
Chemistry, inorganic	423	1.468	1.235
Optics, systems (including communication) and elements	359	0.618	1.231
Coded data generation or conversion	341	0.302	1.218
Communications, electrical	340	1.486	1.195
Coating processes	427	0.998	1.193
Registers	235	0.460	1.187
Surgery	604	0.427	1.180
Locks	70	0.411	1.172
Part of the class 532-570 series—organic compounds	564	0.764	1.167
Radiant energy	250	1.724	1.165
Chemistry: Molecular biology and microbiology	435	0.677	1.152
Static structures, e.g., buildings	52	0.554	1.152
Amplifiers	330	0.886	1.148
Chemistry, electrical and wave energy	204	1.257	1.131
Electricity, measuring and testing	324	1.313	1.115

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to Patent and Trademark Office classes that received at least 200 patents from all countries in 1991.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1991," report prepared for the National Science Foundation (Washington, DC: Sept. 1992).

See text table 6–2.

Appendix table 6–19.

Patent classes most emphasized by inventors from Taiwan patenting in the United States: 1981 and 1991

		Activity index	
Patent class	Class number	1981	1991
Locks	70	0.000	9.401
Superconductor technology: Apparatus, material, process	505	0.000	9.401
Closure fasteners	292	0.000	8.735
Metallurgy	75	31.320	8.197
Amusement and exercising devices	272	0.000	8.062
Semiconductor device manufacturing process	437	0.000	7.093
Electricity, conductors and insulators	174	0.000	5.818
Electricity, circuit makers and breakers	200	0.000	5.420
Error detection/correction and fault detection/recovery	371	0.000	5.089
Electrical connectors	439	0.000	4.721
Brushing, scrubbing and general cleaning	15	0.000	4.572
Metal deforming	72	19.517	4.345
Illumination	362	0.000	4.342
Telephonic communications	379	0.000	4.089
Pumps	417	0.000	4.069
Plastic article or earthenware shaping or treating: ap	425	0.000	3.834
Coded data generation or conversion	341	0.000	3.799
Classification undetermined	1	0.000	3.571
Pulse or digital communications	375	0.000	3.179
Supports	248	0.000	3.138
Winding and reeling	242	0.000	3.073
Chemistry, inorganic	423	9.787	3.059
Movable or removable closures	49	0.000	2.732
Stoves and furnaces	126	0.000	2.732
Amusement devices, toys	446	28.350	2.732
Tools	81	0.000	2.654
Electric power conversion systems	363	0.000	2.568
Brakes	188	0.000	2.499
Metal fusion bonding	228	0.000	2.422
Communications, electrical	340	10.229	2.396
Supports, racks	211	0.000	2.360
Fishing, trapping and vermin destroying	43	0.000	2.201
Part of the class 520 series—synthetic resins or natural rubber	523	0.000	2.101
Part of the class 520 series—synthetic resins or natural rubber	525	0.000	2.075
Chairs and seats	297	0.000	2.070
Mineral oils: Processes and products	208	0.000	2.039
Electrical audio signal processing and systems	381	0.000	1.887
Radiation imagery chemistry—process, composition or products	430	0.000	1.850
Machine elements and mechanisms	74	0.000	1.781
Part of the class 532-570 series—organic compounds	568	0.000	1.558
Fluid sprinkling, spraying and diffusing	239	0.000	1.464
Compositions & Ceramic	501	0.000	1.426
Amusement devices, games	273	0.000	1.406
Package making	53	0.000	1.390
Receptacles	220	0.000	1.314
Electricity, motive power systems	318	0.000	1.311
Electric lamp and discharge devices, systems	315	0.000	1.224
Dynamic information storage or retrieval	369	0.000	1.175
Static information storage and retrieval	365	0.000	1.170
Electrical generator or motor structure	310	0.000	1.144

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to Patent and Trademark Office classes that received at least 200 patents from all countries in 1991.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, "Country Activity Index Report, Corporate Patenting 1991," report prepared for the National Science Foundation (Washington, DC: Sept. 1992).

See text table 6–3.

Appendix table 6–20.

Patent classes most emphasized by inventors from South Korea patenting in the United States: 1981 and 1991

Patent class	Class number	Activity index	
		1981	1991
Electric lamp and discharge devices	313	0.000	21.374
Semiconductor device manufacturing process	437	0.000	10.194
Static information storage and retrieval	365	0.000	9.010
Telephonic communications	379	0.000	6.995
Pictorial communication; television	358	0.000	6.528
Electrical transmission or interconnection systems	307	0.000	6.517
Dynamic magnetic information storage or retrieval	360	0.000	6.131
Pulse or digital communications	375	0.000	4.079
Electric heating	219	0.000	3.741
Gas separation	55	0.000	3.726
Registers	235	0.000	3.666
Joints and connections	403	0.000	3.650
Multiplex communications	370	0.000	3.310
Electric lamp and discharge devices, systems	315	0.000	3.142
Active solid state devices, e.g., transistors, solid state diodes	357	0.000	2.659
Error detection/correction and fault detection/recovery	371	0.000	2.612
Sheet feeding or delivering	271	0.000	2.527
Metal fusion bonding	228	0.000	2.486
Refrigeration	62	0.000	2.463
Winding and reeling	242	0.000	2.366
Telecommunications	455	0.000	2.260
Part of the class 520 series—synthetic resins or natural rubber	528	25.612	1.947
Electrical audio signal processing and systems	381	0.000	1.937
X-ray or gamma ray systems or devices	378	0.000	1.873
Optics, systems (including communication) and elements	359	0.000	1.867
Dynamic information storage or retrieval	369	0.000	1.810
Metal treatment	148	0.000	1.802
Typewriting machines	400	0.000	1.752
Electricity, electrical systems and devices	361	0.000	1.496
Compositions & Ceramic	501	0.000	1.464
Metallurgy	75	0.000	1.402
Stoves and furnaces	126	0.000	1.402
Amusement devices, toys	446	0.000	1.402
Land vehicle	280	0.000	1.380
Tools	81	0.000	1.362
Electricity, motive power systems	318	0.000	1.346
Part of the class 532-570 series—organic compounds	560	0.000	1.265
Chemistry: Analytical and immunological testing	436	0.000	1.243
Communications, electrical	340	0.000	1.230
Part of the class 532-570 series—organic compounds	556	0.000	1.206
Amplifiers	330	0.000	1.181
Coating processes	427	0.000	1.172
Part of the class 520 series—synthetic resins or natural rubber	523	0.000	1.078
Chairs and seats	297	0.000	1.062
Special receptacle or package	206	0.000	1.001
Coded data generation or conversion	341	0.000	0.975
Electricity, circuit makers and breakers	200	0.000	0.927
Animal husbandry	119	0.000	0.918
Machine elements and mechanisms	74	0.000	0.914
Amusement devices, games	273	0.000	0.722

NOTES: The activity index is the percentage of the patents in a class that are granted to inventors from one country, divided by the percentage of all patents that have inventors from that country in that year. Listing is limited to Patent and Trademark Office classes that received at least 200 patents from all countries in 1991.

SOURCE: Office of Information Systems, TAF Program, Patent and Trademark Office, for the National Science Foundation (Washington, DC: Sept. 1992).

See text table 6–3.

Appendix table 6–21.

Patents granted in selected countries, by residence of inventor: 1985–90

(page 1 of 2)

Granting country	Total patents	Patents to nonresidents as percent of total	Residence of inventor									
			United States	Japan	West Germany	France	United Kingdom	Italy	Sweden	India	Former Soviet Union	Other
			1985									
			Percentage of nonresident patents									
Japan	50,100	15.5	46.4	0.0	19.6	6.4	5.4	1.5	2.3	0.0	1.4	17.0
West Germany	33,377	60.4	29.2	23.9	0.0	12.4	6.7	2.8	2.8	0.0	1.7	20.5
France	37,530	73.8	27.4	15.8	25.9	0.0	5.9	4.1	2.4	0.0	1.3	17.0
United Kingdom	34,480	82.3	28.6	20.8	20.9	8.4	0.0	2.9	2.2	0.0	0.6	15.6
Italy	47,924	79.0	6.1	2.3	8.0	4.2	2.0	0.0	0.4	0.0	0.0	77.0
Canada	18,697	92.8	54.8	11.7	8.8	5.6	5.3	1.5	1.8	0.0	0.4	10.0
Mexico	1,374	93.4	56.3	6.6	7.6	7.0	4.0	2.6	1.5	0.0	0.5	14.0
Brazil	3,934	84.6	37.0	7.3	20.7	9.9	4.0	4.6	2.8	0.0	0.4	13.3
South Korea	2,268	84.6	30.4	42.3	6.2	5.4	3.5	1.8	1.4	0.0	0.0	9.1
Soviet Union	74,745	2.0	13.7	8.4	16.9	8.2	3.1	3.9	2.7	0.0	0.0	42.9
India	1,814	76.2	33.5	6.4	11.2	8.1	10.1	3.4	1.3	0.0	3.0	23.0
			1986									
Japan	59,900	14.4	46.1	0.0	20.0	6.7	5.3	2.0	2.2	0.0	1.4	16.3
West Germany	38,995	60.6	30.6	24.1	0.0	11.6	6.8	2.8	2.9	0.0	1.1	20.1
France	35,549	73.7	27.8	17.1	25.4	0.0	6.2	3.8	2.3	0.0	0.7	16.7
United Kingdom	32,929	83.6	28.7	19.9	21.6	8.3	0.0	2.8	2.2	0.0	0.4	16.1
Italy	52,493	23.9	24.9	8.2	28.4	13.8	7.4	0.0	1.5	0.0	0.0	15.8
Canada	17,550	92.2	56.0	12.2	7.9	5.2	5.3	1.8	1.8	0.0	0.2	9.6
Mexico	1,222	96.2	61.3	5.6	7.6	6.6	3.2	2.5	1.3	0.1	0.3	11.5
Brazil	2,935	84.9	38.2	9.6	18.8	7.2	3.5	4.3	2.7	0.0	0.2	15.4
South Korea	1,894	75.8	25.4	58.6	0.0	3.1	2.2	1.7	0.8	0.1	0.0	8.1
Soviet Union	79,367	1.6	14.4	7.3	17.4	9.6	5.0	3.4	3.8	0.0	0.0	39.1
India	1,994	75.2	32.3	7.6	6.3	6.5	14.7	4.5	1.8	0.0	2.8	23.5
			1987									
Japan	62,400	13.3	46.0	0.0	19.8	7.3	4.9	2.5	2.1	0.0	1.6	15.8
West Germany	39,897	59.4	29.2	25.4	0.0	11.2	6.4	3.2	3.1	0.0	1.3	20.3
France	30,413	72.0	26.0	16.9	26.3	0.0	6.1	4.2	2.6	0.0	0.8	17.2
United Kingdom	28,659	83.9	27.6	20.1	22.0	9.1	0.0	2.8	2.4	0.0	0.4	15.6
Italy	11,550	99.0	23.0	8.7	28.3	14.6	7.0	0.0	2.1	0.0	0.0	16.4
Canada	14,649	92.6	54.3	11.6	8.9	5.2	5.6	1.6	2.0	0.0	0.2	10.6
Mexico	1,406	94.6	54.5	7.4	8.2	6.8	3.6	3.4	1.4	0.0	0.5	14.3
Brazil	2,184	86.8	38.9	7.3	17.9	9.4	3.9	4.3	2.4	0.0	0.5	15.4
South Korea	2,330	74.4	27.2	55.9	3.4	1.9	1.0	1.8	1.2	0.0	0.0	7.6
Soviet Union	85,018	1.6	13.8	8.3	16.8	8.5	3.8	5.3	3.7	0.1	0.0	39.8
India	2,027	73.1	37.4	5.8	9.1	8.0	11.6	3.2	2.0	0.0	1.6	21.2

(continued)

Appendix table 6–21.

Patents granted in selected countries, by residence of inventor: 1985–90

(page 2 of 2)

			Residence of inventor									
Granting country	Total patents	Patents to nonresidents as percent of total	United States	Japan	West Germany	France	United Kingdom	Italy	Sweden	India	Former Soviet Union	Other
1988												
			Percentage of nonresident patents									
Japan	55,300	13.4	43.7	0.0	21.8	7.3	5.0	2.2	2.0	0.0	1.5	16.5
West Germany	38,890	59.6	27.9	26.0	0.0	12.0	6.8	3.2	2.8	0.0	0.9	20.3
France	31,956	72.4	25.0	17.2	27.5	0.0	6.0	4.0	2.2	0.0	0.7	17.3
United Kingdom	29,564	85.0	25.5	20.0	23.0	9.7	0.0	3.0	2.1	0.0	0.3	16.3
Italy	25,195	88.9	12.8	5.3	17.6	8.6	4.2	0.0	1.1	0.0	0.0	50.3
Canada	16,813	93.0	55.0	12.8	8.6	4.7	5.1	1.6	1.9	0.0	0.2	10.1
Mexico	3,411	92.0	58.0	6.3	7.7	7.0	3.0	3.2	2.0	0.0	0.2	12.5
Brazil	3,040	84.0	41.2	6.5	16.1	8.8	7.7	4.6	2.2	0.0	0.4	12.5
South Korea	2,174	73.6	29.0	47.7	6.0	3.6	3.3	1.8	0.9	0.0	0.0	7.8
Soviet Union	83,983	1.6	12.7	9.2	22.2	6.4	4.3	3.2	3.2	0.2	0.0	38.6
India	3,454	75.1	35.9	6.1	11.3	9.1	11.5	2.2	2.1	0.0	2.9	18.9
1989												
Japan	63,301	13.5	44.4	0.0	21.2	7.6	5.0	2.2	2.3	0.0	1.3	16.0
West Germany	42,233	60.0	28.2	27.2	0.0	10.9	6.5	3.5	2.8	0.0	0.9	20.0
France	32,879	74.8	24.9	17.5	27.8	0.0	6.0	4.4	2.2	0.0	0.5	16.7
United Kingdom	30,897	86.3	25.7	20.4	23.2	9.1	0.0	3.2	2.1	0.0	0.3	16.0
Italy	15,832	98.7	22.8	9.1	29.4	12.9	6.7	0.0	2.4	0.0	0.0	16.7
Canada	16,299	93.4	52.9	13.7	8.6	6.1	5.7	1.8	1.7	0.0	0.2	9.4
Mexico	2,268	91.0	63.1	4.5	7.8	6.0	2.8	3.5	1.4	0.0	0.7	10.3
Brazil	3,510	86.5	41.2	5.2	16.2	9.1	10.0	4.3	2.2	0.0	0.6	11.1
South Korea	3,972	70.3	30.7	50.6	5.1	3.0	3.0	0.9	0.8	0.0	0.0	6.0
Soviet Union	84,577	1.5	13.6	8.3	19.5	7.0	4.1	4.8	1.9	0.0	0.0	40.8
India	1,986	78.0	35.4	6.8	14.0	7.2	7.3	2.8	1.7	0.0	5.0	19.6
1990												
Japan	59,401	15.2	45.5	0.0	21.3	7.7	5.1	2.4	2.4	0.0	1.1	14.4
West Germany	42,860	61.2	27.8	28.4	0.0	10.8	6.5	3.7	2.7	0.0	0.7	19.3
France	35,149	74.6	24.9	18.2	26.9	0.0	6.0	4.2	2.2	0.0	0.6	17.0
United Kingdom	32,179	86.4	25.6	20.8	22.8	9.1	0.0	3.2	2.0	0.0	0.4	15.9
Italy	17,794	98.7	23.7	9.4	28.5	12.4	6.8	0.0	2.4	0.0	0.1	16.7
Canada	14,187	92.2	52.2	13.7	8.3	6.0	5.4	2.0	1.8	0.0	0.3	10.3
Mexico	1,752	92.0	63.4	5.4	7.3	5.1	3.2	2.4	0.8	0.1	0.2	12.2
Brazil	3,355	86.5	41.4	6.6	16.1	9.4	7.4	4.4	2.3	0.0	0.7	11.8
South Korea	7,762	67.1	23.0	66.7	2.5	1.8	0.8	1.1	0.3	0.0	0.0	3.8
Soviet Union	84,658	1.4	12.0	8.1	18.8	7.8	3.6	6.7	3.8	0.0	0.0	39.2
India	1,611	81.0	35.3	9.3	14.6	6.2	7.8	3.1	1.2	0.0	3.4	19.1

SOURCE: World Intellectual Property Organization, "Industrial Property Statistics" (Geneva, Switzerland: 1985-90).

See figures 6–21 and 6–22.

Appendix table 6–22.

Number of international patent families in robot technology, by year of patent application and priority country: 1980–90

		Priority country						
	Total	United States	Japan	West Germany	Great Britain	France	East Germany	South Korea
Total	3,264	761	1,280	561	197	398	56	10
1980	117	21	52	26	4	14	0	NA
1981	152	31	41	26	15	28	10	NA
1982	219	52	114	26	15	12	0	NA
1983	301	88	109	52	16	26	10	NA
1984	333	57	145	79	28	24	0	0
1985	356	88	124	63	25	50	5	0
1986	382	109	145	63	14	46	5	0
1987	371	78	161	58	26	42	5	2
1988	428	98	150	68	19	76	15	0
1989	308	67	109	58	22	42	5	5
1990	298	72	130	42	13	38	0	3

NA = not available

NOTES: An international patent family is created when patent protection is sought outside of the priority country. Data are estimated from stratified random sampling of database records.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

See figure 6–23. *Science & Engineering Indicators – 1993*

Appendix table 6–23.

Patent families, highly cited families, and citation ratios for robot technology, by priority country: 1981–90

Priority country	Number of families	Number of highly cited families[1]	Country share of total	Country share of highly cited	Citation ratio[2]
			Percent		
			1981–85 period		
Total	3,891	53	100.0	100.0	1.0
United States	745	5	19.1	9.6	0.5
Japan	1,606	36	41.3	67.5	1.6
West Germany	472	5	12.1	9.8	0.8
Great Britain	172	1	4.4	1.9	0.4
France	266	6	6.8	11.2	1.6
East Germany	612	0	15.7	0.0	0.0
South Korea	18	0	0.5	0.0	0.0
			1986–90 period		
Total	5,539	64	100.0	100.0	1.0
United States	1,061	26	19.2	40.5	2.1
Japan	2,533	26	45.7	40.5	0.9
West Germany	803	5	14.5	8.2	0.6
Great Britain	148	1	2.7	1.6	0.6
France	425	6	7.7	9.4	1.2
East Germany	546	0	9.9	0.0	0.0
South Korea	23	0	0.4	0.0	0.0

[1] A patent family was considered highly cited if the number of citations it received ranked it within the top 1 percent compared with all other robot technology patent families.

[2] A citation ratio of greater than 1.0 indicates that a country has a higher share of highly cited patent families than would be expected based on its share of total families.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

See text table 6–5. *Science & Engineering Indicators – 1993*

Appendix table 6–24.

Number of international patent families in genetic engineering, by year of patent application and priority country: 1980–90

		Priority country						
	Total	United States	Japan	West Germany	Great Britain	France	East Germany	South Korea
Total	2,415	1,392	489	197	230	95	6	6
1980	25	18	3	0	4	0	0	0
1981	48	21	17	3	6	1	0	0
1982	87	64	8	4	10	1	0	0
1983	129	73	36	5	12	2	1	0
1984	185	109	52	9	11	3	1	0
1985	229	141	51	16	16	5	0	0
1986	206	97	57	17	20	11	1	3
1987	212	124	41	22	15	9	0	1
1988	370	206	59	39	46	17	2	1
1989	483	273	85	43	54	26	1	1
1990	441	266	80	39	36	20	0	0

NOTES: An international patent family is created when patent protection is sought outside of the priority country. Data are estimated from stratified random sample of database records.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

See figure 6–24. *Science & Engineering Indicators – 1993*

Appendix table 6–25.

Patent families, highly cited families, and citation ratios for genetic engineering, by priority country: 1981–90

Priority country	Number of families	Number of highly cited families[1]	Country share of total	Country share of highly cited	Citation ratio[2]
			Percent		
			1981–85 period		
Total	1,036	11	100.0	100.0	1.0
United States	530	8	51.2	72.7	1.4
Japan	373	2	36.0	18.2	0.5
West Germany	40	0	3.9	0.0	0.0
Great Britain	57	1	5.5	9.1	1.7
France	17	0	1.6	0.0	0.0
East Germany	19	0	1.8	9.8	0.8
South Korea	NA	NA	NA	NA	NA
			1986–90 period		
Total	3,020	35	100.0	100.0	1.0
United States	1,125	23	37.3	65.7	1.8
Japan	1,317	6	43.6	17.1	0.4
West Germany	196	0	6.5	0.0	0.0
Great Britain	184	5	6.1	14.3	2.3
France	99	1	3.3	2.9	0.9
East Germany	64	0	2.1	0.0	0.0
South Korea	35	0	1.2	0.0	0.0

NA = not available

[1] A patent family was considered highly cited if the number of citations it received ranked it within the top 1 percent compared with all other genetic engineering patent families.

[2] A citation ratio of greater than 1.0 indicates that a country has a higher share of highly cited patent families than would be expected based on its share of total families.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

See text table 6–8. *Science & Engineering Indicators – 1993*

Appendix table 6–26.

Number of international patent families in optical fiber technology, by year of patent application and priority country: 1980–90

		Priority country						
	Total	United States	Japan	West Germany	Great Britain	France	East Germany	South Korea
Total	1,872	559	684	315	165	133	10	6
1980	61	23	14	10	5	9	0	NA
1981	95	32	39	10	9	5	0	NA
1982	104	37	42	12	6	7	0	NA
1983	114	35	39	22	11	6	0	1
1984	145	37	69	17	12	8	0	2
1985	195	46	72	44	22	10	1	0
1986	176	51	67	34	17	6	1	0
1987	236	59	102	35	15	20	5	0
1988	251	71	81	48	30	20	1	0
1989	234	83	74	38	19	16	2	2
1990	261	85	85	45	19	26	0	1

NA = not available

NOTES: An international patent family is created when patent protection is sought outside of the priority country. Data are estimated from stratified random sample of database records.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

See figure 6–25. *Science & Engineering Indicators – 1993*

Appendix table 6–27.

Patent families, highly cited families, and citation ratios for optical fiber technology, by priority country: 1981–90

Priority country	Number of families	Number of highly cited families[1]	Country share of total	Country share of highly cited	Citation ratio[2]
			Percent		
		1981–85 period			
Total	2,043	22	100.0	100.0	1.0
United States	368	8	18.0	36.4	2.0
Japan	1,299	12	63.6	54.5	0.9
West Germany	175	1	8.6	4.5	0.5
Great Britain	95	1	4.7	4.5	1.0
France	66	0	3.2	0.0	0.0
East Germany	37	0	1.8	0.0	0.0
South Korea	3	0	0.1	0.0	0.0
		1986–90 period			
Total	4,717	79	100.0	100.0	1.0
United States	718	31	15.2	39.2	2.6
Japan	3,245	25	68.8	31.6	0.5
West Germany	389	7	8.2	8.9	1.1
Great Britain	169	10	3.6	12.7	3.5
France	125	6	2.6	7.6	2.9
East Germany	66	0	1.4	0.0	0.0
South Korea	5	0	0.1	0.0	0.0

[1] A patent family was considered highly cited if the number of citations it received ranked it within the top 1 percent compared with all other optical fiber technology patent families.

[2] A citation ratio of greater than 1.0 indicates that a country has a higher share of highly cited patent families than would be expected based on its share of total families.

SOURCE: World Patents Index database (London: Derwent Publications, LTD), special tabulations by Mogee Research & Analysis Associates under contract to the National Science Foundation.

See text table 6–11. *Science & Engineering Indicators – 1993*

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Appendix table 6–28.

High-tech companies formed in the United States: 1980–93

Period formed	All high-tech fields	Automation	Biotechnology	Computer hardware	Advanced materials	Photonics & optics	Software	Electronic components	Telecom-munications	Other fields[1]
Number of companies										
Total, all years	22,728	1,534	558	2,176	869	823	5,644	2,611	1,267	7,246
1980-93	10,957	490	358	1,253	243	296	3,395	807	593	3,522
1980-84	5,659	315	178	683	137	171	2,026	453	324	1,372
1985-89	4,660	150	150	489	88	100	1,131	299	239	2,014
1990-93	638	25	30	81	18	25	238	55	30	136
Percentage of all high-tech companies formed during each period										
Total, all years	100.0	6.7	2.5	9.6	3.8	3.6	24.8	11.5	5.6	31.9
1980-93	100.0	4.5	3.3	11.4	2.2	2.7	31.0	7.4	5.4	32.1
1980-84	100.0	5.6	3.1	12.1	2.4	3.0	35.8	8.0	5.7	24.2
1985-89	100.0	3.2	3.2	10.5	1.9	2.1	24.3	6.4	5.1	43.2
1990-93	100.0	3.9	4.7	12.7	2.8	3.9	37.3	8.6	4.7	21.3
Percentage of total U.S. high-tech companies, by field										
Total, all years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1980-93	48.2	31.9	64.2	57.6	28.0	36.0	60.2	30.9	46.8	48.6
1980-84	24.9	20.5	31.9	31.4	15.8	20.8	35.9	17.3	25.6	18.9
1985-89	20.5	9.8	26.9	22.5	10.1	12.2	20.0	11.5	18.9	27.8
1990-93	2.8	1.6	5.4	3.7	2.1	3.0	4.2	2.1	2.4	1.9

NOTE: Data reflect information collected on new high-tech companies formed through June 1993.

[1] Other fields are chemicals, defense-related, energy, environmental, manufacturing equipment, medical, pharmaceuticals, subassemblies and components, test and measurement, and transportation.

SOURCE: CorpTech database Rev. 8.2 (Wellesley Hills, MA: Corporate Technology Information Services, Inc.), special tabulations.

See figure 6–26.

Science & Engineering Indicators – 1993

Appendix table 6–29.

Ownership of companies active in high-tech fields operating in the United States, by country of ownership: 1993

Country	All fields	Automation	Biotechnology	Computer hardware	Advanced materials	Photonics & optics	Software	Electronic components	Telecommunications	Other fields[1]
					Number of companies					
Total	22,728	1,534	558	2,176	869	823	5,644	2,611	1,267	7,246
United States	21,246	1,385	517	1,997	763	753	5,523	2,404	1,174	6,730
Foreign	1,482	149	41	179	106	70	121	207	93	516
United Kingdom	375	31	8	27	25	20	41	57	16	150
Japan	269	25	6	57	20	17	7	53	26	58
Germany	222	39	4	14	28	17	5	30	8	77
France	125	10	0	11	11	4	16	16	6	51
Switzerland	120	17	3	5	4	3	4	17	2	65
Canada	90	5	1	9	3	3	18	6	15	30
Sweden	60	8	6	6	3	1	3	6	3	24
Taiwan	26	1	0	16	0	2	0	1	6	0
South Korea	9	0	1	3	1	0	1	2	1	0
					Percent					
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
United States	93.5	90.3	92.7	91.8	87.8	91.5	97.9	92.1	92.7	92.9
Foreign	6.5	9.7	7.3	8.2	12.2	8.5	2.1	7.9	7.3	7.1
United Kingdom	1.6	2.0	1.4	1.2	2.9	2.4	0.7	2.2	1.3	2.1
Japan	1.2	1.6	1.1	2.6	2.3	2.1	0.1	2.0	2.1	0.8
Germany	1.0	2.5	0.7	0.6	3.2	2.1	0.1	1.1	0.6	1.1
France	0.5	0.7	0.0	0.5	1.3	0.5	0.3	0.6	0.5	0.7
Switzerland	0.5	1.1	0.5	0.2	0.5	0.4	0.1	0.7	0.2	0.9
Canada	0.4	0.3	0.2	0.4	0.3	0.4	0.3	0.2	1.2	0.4
Sweden	0.3	0.5	1.1	0.3	0.3	0.1	0.1	0.2	0.2	0.3
Taiwan	0.1	*	*	0.7	*	0.2	*	0.0	0.5	0.0
South Korea	*	*	0.2	0.1	*	*	*	0.1	0.1	0.0

* = less than 0.05 percent

NOTE: Data reflect information collected on new high-tech companies formed through June 1993.

[1] Other fields are chemicals, defense-related, energy, environmental, manufacturing equipment, medical, pharmaceuticals, subassemblies and components, test and measurement, and transportation.

SOURCE: Derived from the CorpTech database Rev. 8.2 (Wellesley Hills, MA: Corporate Technology Information Services, Inc.).

Science & Engineering Indicators – 1993

Appendix table 6–30.

Leading indicators of technological competitiveness for selected Asian countries

Country	National commitment	Socioeconomic infrastructure	Technological infrastructure	Productive capacity
	Standardized Z score			
Newly industrializing economies				
Hong Kong	1.254	0.949	(0.002)	0.273
South Korea	0.924	0.893	1.126	1.065
Singapore	0.983	0.826	1.086	1.023
Taiwan	0.921	1.170	1.226	1.159
Emerging Asian economies				
China	(1.214)	(1.411)	0.384	(0.534)
India	(0.425)	(1.682)	0.275	0.227
Indonesia	(0.847)	(0.566)	(1.160)	(1.764)
Malaysia	0.385	(0.263)	(0.368)	0.380
Other Asian economies				
The Philippines	(1.364)	(0.179)	(1.443)	(0.652)
Thailand	(0.616)	(0.094)	(1.124)	(1.176)

NOTE: Scores were normalized to median values of zero for the 10 countries, based on surveys of expert opinion conducted in 1990 and statistical data for the late 1980s.

SOURCE: J. David Roessner, *The Capacity for Modernization Among Selected Nations of Asia and the Pacific Rim*, final report prepared for Joint Management Services, Inc. (Atlanta: Georgia Institute of Technology, 1992).

See figure 6–27.

Appendix table 7–1.
Public interest in selected issues: 1979–92

Issue area	Degree of interest	1979	1981	1983	1985	1988	1990	1992
					Percent			
International and foreign policy	Very	22	35	30	33	33	48	38
	Moderately	53	47	47	51	50	40	47
	Not at all	24	18	22	16	16	12	15
New scientific discoveries	Very	36	37	48	44	43	39	36
	Moderately	49	45	40	44	46	48	49
	Not at all	14	17	11	12	12	12	15
Use of new inventions and technologies	Very	33	33	42	39	40	39	37
	Moderately	51	50	45	49	48	49	53
	Not at all	15	16	12	12	12	12	10
Space exploration	Very	NA	25	27	29	34	26	22
	Moderately	NA	44	45	46	44	48	50
	Not at all	NA	31	28	25	22	26	28
Energy/nuclear power[1]	Very	46	50	39	36	38	42	32
	Moderately	42	40	46	50	46	44	49
	Not at all	11	10	14	13	16	14	18
New medical discoveries	Very	NA	NA	NA	68	75	68	66
	Moderately	NA	NA	NA	29	25	29	31
	Not at all	NA	NA	NA	3	3	3	3
Environmental pollution	Very	NA	NA	NA	NA	NA	64	59
	Moderately	NA	NA	NA	NA	NA	31	36
	Not at all	NA	NA	NA	NA	NA	5	5
Economic issues and business conditions	Very	35	52	57	48	48	50	56
	Moderately	48	37	33	41	42	40	36
	Not at all	17	10	10	11	10	10	8
	N =	1,635	3,195	1,631	2,005	2,041	2,033	2,001

"There are a lot of issues in the news and it is hard to keep up with every area. I'm going to read you a short list of issues and for each one—as I read it—I would like you to tell me if you are very interested, moderately interested, or not at all interested."

NA = not asked

NOTES: "Don't know" responses are not included. Percentages may not total 100 because of rounding.

[1] In 1988, 1990, and 1992, the question was worded, ". . . issues about the use of nuclear power to generate electricity." In 1979 to 1985, the question was worded ". . . issues about energy policy."

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–1.

Appendix table 7–2.

Public interest in scientific and technological issues, by sex and level of education: 1992

Sex and level of education	Science		Technology		Medicine		Space		Nuclear power		Environment		
	Very interested	Moderately interested	Very interested	Moderately interested	Very interested	Moderately interested	Very interested	Moderately interested	Very interested	Moderately interested	Very interested	Moderately interested	N
	Percent												
All adults	36	49	37	53	66	31	22	50	32	49	59	36	2,001
Sex													
Male	38	49	41	52	55	40	29	50	33	48	55	39	950
Female	34	49	33	55	76	23	16	51	30	50	62	34	1,051
Formal education													
9 years or less	32	39	34	52	74	22	18	36	38	37	62	30	196
10 or 11 years	33	47	46	44	71	25	23	48	39	42	60	30	207
High school degree	35	51	35	55	66	31	21	51	30	49	59	37	1,202
College degree	43	51	39	55	62	35	25	55	30	56	58	40	235
Graduate/professional degree	44	51	40	52	57	40	26	56	27	61	54	42	161
Science/math education													
Low	33	48	36	53	70	27	20	47	34	45	60	35	1,175
Middle	36	53	35	54	62	36	24	53	27	54	55	39	467
High	47	48	41	52	59	38	27	58	29	55	60	37	358

"There are a lot of issues in the news and it is hard to keep up with every area. I'm going to read you a short list of issues and for each one—as I read it—I would like you to tell me if you are very interested, moderately interested, or not at all interested."

NOTES: "Don't know" responses are not included. Percentages may not total 100 because of rounding.

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–2.

Science & Engineering Indicators – 1993

Appendix table 7–3.
International comparisons of public interest in scientific and technological issues: 1992

	Public interest in				
Region/country	New medical discoveries	New inventions and technologies	New scientific discoveries	Environmental pollution	N
	Percent				
European Community	45	35	38	56	12,800
Belgium	36	28	29	42	1,000
Denmark	39	36	39	61	1,000
France	58	42	46	59	1,000
Germany	35	25	26	55	2,000
Greece	55	44	46	74	1,000
Ireland	37	30	29	39	1,000
Italy	45	39	45	65	1,000
Luxembourg	46	36	37	63	500
The Netherlands	57	44	41	63	1,000
Portugal	29	21	22	37	1,000
Spain	39	33	37	50	1,000
United Kingdom	51	39	41	50	1,300
Japan	31	16	13	36	1,457
United States	66	37	36	59	2,001

SOURCES: Commission of the European Communities, *Europeans, Science and Technology – Public Understanding and Attitudes* [Eurobarometer 38.1] (Brussels: Commission of the European Communities, 1993). J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979-1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and National Institute of Science and Technology Policy (Japan), *Japan National Study, 1991* (Tokyo: NISTEP, 1992).

See figure 7–3.

Appendix table 7–4.

Public informedness on selected issues: 1979–92

Issue area	Degree of informedness	1979	1981	1983	1985	1988	1990	1992
		Percent						
International and foreign policy	Very well-informed	8	17	14	15	14	22	19
	Moderately well-informed	54	54	51	53	55	57	54
	Not at all informed	37	28	35	32	31	22	26
New scientific discoveries	Very well-informed	10	13	13	13	14	14	12
	Moderately well-informed	52	49	53	59	55	55	54
	Not at all informed	37	38	34	27	31	31	34
Use of new inventions and technologies	Very well-informed	10	11	14	12	12	11	10
	Moderately well-informed	50	48	55	54	51	53	56
	Not at all informed	39	40	32	34	36	35	33
Space exploration	Very well-informed	NA	14	13	16	13	11	9
	Moderately well-informed	NA	46	52	52	52	51	48
	Not at all informed	NA	40	34	32	34	38	44
Energy/nuclear power[1]	Very well-informed	18	23	19	16	13	12	10
	Moderately well-informed	58	56	56	55	47	50	43
	Not at all informed	23	21	24	29	39	38	46
New medical discoveries	Very well-informed	NA	NA	NA	24	22	24	22
	Moderately well-informed	NA	NA	NA	57	59	57	58
	Not at all informed	NA	NA	NA	18	19	20	21
Environmental pollution	Very well-informed	NA	NA	NA	NA	NA	32	29
	Moderately well-informed	NA	NA	NA	NA	NA	55	56
	Not at all informed	NA	NA	NA	NA	NA	13	15
Economic issues and business conditions	Very well-informed	14	29	28	22	22	25	29
	Moderately well-informed	55	51	52	51	55	55	54
	Not at all informed	31	20	20	26	22	20	17
	N =	1,635	3,195	1,631	2,005	2,041	2,033	2,001

"There are a lot of issues in the news and it is hard to keep up with every area. I'm going to read you a short list of issues and for each one—as I read it—I would like you to tell me if you are very interested, moderately interested, or not at all interested.

"Now, I'd like to go through this list with you again and for each issue I'd like you to tell me if you are very well-informed, moderately well-informed, or poorly informed."

NA = not asked

NOTES: "Don't know" responses are not included. Percentages may not total 100 because of rounding.

[1] In 1988, 1990, and 1992, the question was worded ". . . issues about the use of nuclear power to generate electricity." In 1979 to 1985, the question was worded ". . . issues about energy policy."

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–1.

Science & Engineering Indicators – 1993

Appendix table 7–5.

Public informedness on scientific and technological issues, by sex and level of education: 1992

Sex and level of education	Science		Technology		Medicine		Space		Nuclear power		Environment		
	Very well-informed	Moderately well-informed	Very well-informed	Moderately well-informed	Very well-informed	Moderately well-informed	Very well-informed	Moderately well-informed	Very well-informed	Moderately well-informed	Very well-informed	Moderately well-informed	N
	Percent												
All adults	13	54	11	56	22	58	9	48	11	43	29	56	2,001
Sex													
Male	16	53	13	57	17	56	12	52	12	45	31	54	950
Female	10	55	9	55	26	59	6	44	9	41	28	58	1,051
Formal education													
9 years or less	16	52	18	52	22	52	6	37	16	43	34	46	196
10 or 11 years	13	58	6	61	23	60	6	54	11	42	29	52	207
High school degree	11	50	9	55	21	58	9	47	9	40	28	57	1,202
College degree	12	64	11	58	20	58	10	48	12	47	30	62	235
Graduate/professional degree	17	63	16	58	26	60	16	55	11	57	33	58	161
Science/math education													
Low	11	52	10	54	22	57	8	44	11	41	28	56	1,175
Middle	12	53	8	60	19	58	8	53	8	43	28	58	467
High	18	63	15	58	23	59	13	53	11	49	35	54	358

"There are a lot of issues in the news and it is hard to keep up with every area. I'm going to read you a short list of issues and for each one—as I read it—I would like you to tell me if you are very interested, moderately interested, or not at all interested.

"Now, I'd like to go through this list with you again and for each issue I'd like you to tell me if you are very well-informed, moderately well-informed, or poorly informed."

NOTES: "Don't know" responses are not included. Percentages may not total 100 because of rounding.

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–2.

Science & Engineering Indicators – 1993

Appendix table 7–6.

International comparisons of public informedness on scientific and technological issues: 1992

Region/country	Percent "very well informed" about New medical discoveries	 New inventions and technologies	 New scientific discoveries	 Environmental pollution	N
	Percent				
European Community	12	9	9	25	12,800
Belgium	14	11	9	24	1,000
Denmark	11	12	11	27	1,000
France	20	14	16	30	1,000
Germany	10	7	7	26	2,000
Greece	11	8	8	29	1,000
Ireland	8	8	7	14	1,000
Italy	11	9	9	28	1,000
Luxembourg	16	13	13	34	500
The Netherlands	15	12	10	31	1,000
Portugal	6	4	4	14	1,000
Spain	7	7	6	16	1,000
United Kingdom	13	11	10	23	1,300
Japan	5	2	2	8	1,457
United States	22	10	12	29	2,001

"There are a lot of issues in the news and it is hard to keep up with every area. I'm going to read you a short list of issues and for each one–as I read it–I would like you to tell me if you are very interested, moderately interested, or not at all interested."

'Now I'd like to go through this list with you again and for each issue I'd like you to tell me if you are well-informed, moderately well-informed, or poorly informed."

SOURCES: Commission of the European Communities, *Europeans, Science and Technology – Public Understanding and Attitudes* [Eurobarometer 38.1] (Brussels: Commission of the European Communities, 1993). J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979-1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and National Institute of Science and Technology Policy (Japan), *Japan National Study, 1991* (Tokyo: NISTEP, 1992).

See figure 7–4.

Science & Engineering Indicators – 1993

Appendix table 7–7.

Public attentiveness to selected issues: 1979–92

Issue area	Degree of attentiveness	1979	1981	1983	1985	1988	1990	1992
		Percent						
International and foreign policy	Attentive public	6	6	8	8	8	14	11
	Interested public	16	29	23	25	25	34	27
	Residual	78	65	70	67	67	52	62
New scientific discoveries	Attentive public	7	9	9	8	8	8	7
	Interested public	29	28	40	36	34	31	29
	Residual	64	63	52	56	57	61	64
Use of new inventions and technologies	Attentive public	6	8	8	8	7	7	6
	Interested public	27	26	34	31	33	32	30
	Residual	67	67	58	61	60	61	63
Science and technology	Attentive public	9	12	13	12	11	11	10
	Interested public	37	35	48	44	42	40	40
	Residual	54	54	39	45	46	49	50
Space exploration	Attentive public	NA	7	7	9	8	6	5
	Interested public	NA	18	20	20	26	20	17
	Residual	NA	75	73	71	66	74	78
Energy/nuclear power[1]	Attentive public	NA	NA	15	NA	8	8	6
	Interested public	NA	NA	25	NA	30	34	26
	Residual	NA	NA	61	NA	62	58	68
New medical discoveries	Attentive public	NA	NA	NA	17	16	16	17
	Interested public	NA	NA	NA	51	56	52	49
	Residual	NA	NA	NA	32	28	32	34
Environmental pollution	Attentive public	NA	NA	NA	NA	NA	20	18
	Interested public	NA	NA	NA	NA	NA	43	41
	Residual	NA	NA	NA	NA	NA	36	41
Economic issues and business conditions	Attentive public	9	12	19	16	15	17	19
	Interested public	26	40	38	32	33	34	38
	Residual	65	48	43	52	52	50	44
	N =	1,635	3,195	1,631	2,005	2,041	2,033	2,001

NA = not available

NOTE: Percentages may not total 100 because of rounding.

[1] In 1988, 1990, and 1992, respondents were asked about their interest in, and informedness on, ". . . issues about the use of nuclear power to generate electricity." In 1979 to 1985, they were asked about ". . . issues about energy policy."

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979-1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–1.

Appendix table 7–8.

Public attentiveness to scientific and technological issues, by sex and level of education: 1992

Sex and level of education	Science		Technology		Science/tech policy		Medicine		Space		Nuclear power		Environment		N
	Attentive	Interested	Attentive	Interested	Attentive	Interested	Attentive	Interested	Attentive	Interested	Attentive	Interested	Attentive	Interested	
								Percent							
All adults	7	29	6	31	10	40	17	49	5	17	6	26	18	41	2,001
Sex															
Male	9	30	8	33	13	39	13	43	7	22	7	26	19	36	950
Female	6	28	5	28	8	41	21	55	3	13	5	25	17	45	1,051
Formal education															
9 years or less	4	29	8	26	10	34	12	63	3	16	6	32	13	49	196
10 or 11 years	8	24	6	40	9	51	18	52	2	21	9	30	19	42	207
High school degree	7	28	5	30	9	39	17	49	4	17	5	25	17	42	1,202
College degree	8	35	9	30	12	43	17	45	6	19	8	22	21	37	235
Graduate/professional degree	12	32	11	29	16	37	22	35	11	15	6	21	24	30	161
Science/math education															
Low	6	27	5	31	9	39	17	53	3	16	6	28	17	44	1,175
Middle	7	28	5	30	8	41	14	48	4	19	4	23	15	40	467
High	12	36	11	31	16	42	20	39	9	18	8	22	26	34	358

NOTE: Percentages may not total 100 because of rounding.

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979-1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–5.

Science & Engineering Indicators – 1993B

Appendix table 7–9.

Public use of selected sources of information: 1992

Sex, level of education, and attentiveness	Newspaper	News magazine	Science magazine	TV news	Radio news	Public library	N
	Percent						
All adults	56	28	9	95	64	42	2,001
Sex							
Male	63	30	12	95	66	37	950
Female	50	26	6	94	63	46	1,051
Formal education							
9 years or less	44	8	2	97	51	21	196
10 or 11 years	51	22	7	94	58	22	207
High school degree	56	27	9	95	66	42	1,202
College degree	59	43	13	94	67	60	235
Graduate/professional degree	70	44	14	94	75	65	161
Science/math education							
Low	53	20	7	95	61	30	1,175
Middle	58	36	8	95	69	52	467
High	62	42	17	93	69	65	358
Attentiveness to science/technology policy							
Attentive public	76	44	26	93	63	58	199
Interested public	53	29	9	96	65	41	802
Residual	54	24	5	94	64	39	999

"Now, I'd like to read you a short list of television shows and ask you to tell me whether you watch each show regularly—that is, most of the time—occasionally, or not at all. A morning television news show? An evening television news show? A late night television news show?

"How often do you read a newspaper: every day, a few times a week, once a week, or less than once a week?

"Are there any magazines that you read regularly, that is, most of the time? Are there any others that you read occasionally?

"On an average day, about how many hours would you say that you listen to a radio? About how many of those hours are news reports or news shows?

"Now, let me ask you about your use of museums, zoos, and similar institutions. I am going to read you a short list of places and ask you to tell me how many times you visited each type of place during the last year, that is, the last 12 months. If you did not visit any given place, just say none. A public library: How many times did you visit it during the last year?"

NOTES: "Don't know" responses are not included. Percentages may not total 100 because of rounding.

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979-1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–6.

Science & Engineering Indicators – 1993

Appendix table 7–10.

Primary sources of information about health: 1992

Sex, level of education, and attentiveness	TV	Newspapers	Doctors	Magazines	N
	Percent				
All adults	32	19	14	13	3,111
Sex					
Male	31	22	14	10	1,490
Female	33	16	16	15	1,621
Formal education					
9 years or less	33	7	25	7	346
10 or 11 years	30	10	25	9	338
High school degree	35	20	12	13	1,818
College degree	25	26	9	13	414
Graduate/professional degree	23	21	12	27	195
Science/math education					
Low	34	15	17	12	1,743
Middle	32	23	10	11	853
High	22	24	12	19	515
Attentiveness to science/technology policy					
Attentive public	24	14	16	16	247
Interested public	32	19	14	13	1,261
Residual	33	19	15	12	1,601

"Now, let me ask you to think about news or information about health and medicine. What is your most important source of information about health and medicine?"

NOTES: "Don't know" responses are not included. Percentages may not total 100 because of rounding.

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–7.

Science & Engineering Indicators – 1993

Appendix table 7–11.

Comparisons of public levels of trust in news sources for selected health issues: 1992

Sex, level of education, and attentiveness	A	B	C	D	E	F	G	N
	Percentage with a high level of trust							
Heart disease								
All adults	16	46	28	12	76	54	67	1,483
Sex								
Male	15	45	26	9	77	58	66	675
Female	18	47	31	15	75	51	67	808
Formal education								
9 years or less	26	24	36	25	62	31	48	172
10 or 11 years	19	50	44	20	83	44	64	153
High school degree	14	49	25	10	76	86	68	854
College degree	14	48	22	6	78	64	74	211
Graduate/professional degree	23	45	31	6	75	74	84	94
Science/math education								
Low	17	43	32	15	74	46	61	816
Middle	17	55	27	10	79	59	72	432
High	14	42	19	7	75	74	77	235
Attentiveness to science/technology policy								
Attentive public	15	44	26	15	80	73	73	132
Interested public	17	48	31	11	72	58	69	572
Residual	16	44	27	12	78	48	64	779
Weight loss								
All adults	8	27	17	9	69	39	56	1,628
Sex								
Male	8	26	17	5	72	38	54	815
Female	8	28	18	14	67	40	58	813
Formal education								
9 years or less	3	8	16	13	46	28	36	174
10 or 11 years	12	15	23	14	57	19	47	186
High school degree	7	28	18	10	73	41	58	964
College degree	13	42	18	3	77	46	69	203
Graduate/professional degree	6	35	4	3	81	59	67	101
Science/math education								
Low	7	20	20	12	64	35	49	927
Middle	10	31	15	6	76	42	64	421
High	9	43	13	6	79	49	67	280
Attentiveness to science/technology policy								
Attentive public	12	38	22	6	71	53	70	115
Interested public	11	29	19	11	75	46	62	690
Residual	5	23	16	8	64	32	49	823

"Earlier we talked about the sources from which you get your information about various issues. Now, I would like to ask you to tell me how much confidence or trust you would have in various kinds of information about heart disease (losing weight). Let me read you a short list of news sources that might include some information about heart disease (losing weight), and, for each one, I would like you to tell me if you have a high level of confidence in information from that source, a moderate level of confidence, or a low level of confidence."

A = A story in your local newspaper
B = An article in *Time* or *Newsweek*
C = A story on the evening television news
D = A television talk show like the Oprah Winfrey Show or the Phil Donahue Show
E = A conversation with your physician
F = An article by a scientist
G = A report from the National Institutes of Health

NOTES: "Don't know" responses are not included. Percentages may not total 100 because of rounding.

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979-1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–8.

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Appendix table 7–12.

Public confidence in the people running various institutions: 1973–93

Institution	1973	1974	1975	1976	1977	1978	1980	1982	1983	1984	1986	1987	1988	1989	1990	1993
	Percentage expressing a great deal of confidence															
Average[1]	30	33	26	29	31	24	26	26	24	27	25	28	26	25	30	23
Medicine	54	60	50	54	51	46	52	45	51	50	46	52	51	46	46	40
Scientific community	37	45	38	43	41	36	41	38	41	44	39	45	39	40	37	41
U.S. Supreme Court	31	33	31	35	35	28	25	30	28	33	30	36	35	34	35	32
Military	32	40	35	39	36	29	28	31	29	36	31	34	34	32	33	43
Education	37	49	31	37	41	28	30	33	29	28	28	35	29	30	27	23
Major companies	29	31	19	22	27	22	27	23	24	30	24	30	25	24	25	22
Organized religion	35	44	24	30	40	31	35	32	28	31	25	29	20	22	23	24
Executive branch of Federal Govt.	29	14	13	13	28	12	12	19	13	18	21	18	16	20	NA	12
Banks and financial institutions	NA	NA	32	39	42	33	32	27	24	31	21	27	27	19	NA	15
Congress	23	17	13	14	19	13	9	13	10	12	16	16	15	17	NA	7
Press	23	26	24	28	25	20	22	18	13	17	18	18	18	17	15	11
TV	18	23	18	19	17	14	16	14	12	13	15	12	14	14	NA	12
Organized labor	15	18	10	12	15	11	15	12	8	8	8	10	10	9	NA	9
N =	1,504	1,484	1,490	1,499	1,530	1,532	1,468	1,506	1,599	989	1,470	1,466	997	1,035	899	1,031

"I am going to name some institutions in this country. As far as the people running these institutions are concerned, would you say you have a great deal of confidence, only some confidence, or hardly any confidence at all in them?"

NA = not asked

NOTE: Survey was not conducted in 1979 and 1981, and question was not asked in 1985.

[1] Average does not include banks and financial institutions.

SOURCE: National Opinion Research Center, *General Social Surveys, Cumulative Codebook*, J.A. Davis and T.W. Smith, principal investigators (Chicago: University of Chicago, annual series).

See figure 7–9.

Science & Engineering Indicators – 1993

Appendix table 7–13.
Responses to and mean scores on the Attitude Toward Organized Science Scale: 1983–92

	1983	1985	1988	1990	1992
			Percentage of public		
Agree that "science and technology are making our lives healthier, easier and more comfortable"	84	86	87	84	85
Agree that "the benefits of science are greater than any harmful effects"	57	68	76	72	73
Disagree that "science makes our way of life change too fast"	50	53	59	60	63
Disagree that "we depend too much on science and not enough on faith"	43	39	43	44	45
			Mean ATOSS score		
All adults	2.3	2.5	2.7	2.6	2.7
Sex					
Male	2.2	2.4	2.6	2.5	2.7
Female	2.5	2.6	2.8	2.8	2.6
Formal education					
11 years or less	1.8	1.8	2.2	1.8	2.0
High school degree	2.4	2.6	2.8	2.7	2.7
College degree	2.8	3.1	3.2	3.2	3.2
Graduate/professional degree	2.9	3.1	3.1	3.2	3.3
Attentiveness to science/technology policy					
Attentive public	2.6	2.8	3.0	2.8	2.9
Interested public	2.4	2.6	2.8	2.7	2.8
Residual	2.1	2.3	2.5	2.5	2.5
N =	1,631	2,005	2,041	2,033	2,001

"Now I would like to read you some statements like those you might find in a newspaper or magazine article. For each statement, please tell me if you generally agree or disagree. If you feel especially strongly about a statement, please tell me that you strongly agree or strongly disagree."

ATOSS = Attitute Toward Organized Science Scale

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979-1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See text table 7–2.

Appendix table 7–14.
International comparisons of public attitudes toward science and technology: 1992

Region/country	A	B	C	D	E	F	G	N
	Percentage agreeing							
European Community	83	48	19	80	54	61	55	6,418
Belgium	76	37	20	77	59	51	48	495
Denmark	86	46	17	81	19	69	62	511
France	84	44	14	86	49	63	48	505
Germany	86	48	24	75	70	60	62	1,001
Greece	83	63	23	86	53	61	89	500
Ireland	76	48	16	75	41	63	48	495
Italy	80	45	19	82	56	62	54	491
Luxembourg	76	46	24	78	57	55	59	257
The Netherlands	85	44	19	84	80	50	58	479
Portugal	76	61	24	69	49	60	66	505
Spain	81	53	17	71	42	67	65	497
United Kingdom	85	49	17	83	40	61	47	674
Japan	NA	70	43	86	NA	40	57	1,457
United States	84	48	39	76	38	73	38	2,001

A *"Science and technology are making our lives healthier, easier, and more comfortable."*
B *"We depend too much on science and not enough on faith."*
C *"On balance, computers and factory automation will create more jobs than they eliminate."*
D *"Even if it brings no immediate benefits, scientific research which advances the frontiers of knowledge is necessary and should be supported by the government."*
E *"New inventions will always be found to counteract any harmful consequences of technological development."*
F *"The benefits of science are greater than any harmful effects."*
G *"Science and technology make our way of life change too fast."*

NA = not asked

SOURCES: Commission of the European Communities, *Europeans, Science and Technology – Public Understanding and Attitudes* [Eurobarometer 38.1] (Brussels: Commission of the European Communities, 1993). J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979-1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and National Institute of Science and Technology Policy (Japan), *Japan National Study, 1991* (Tokyo: NISTEP, 1992).

See figure 7–14. *Science & Engineering Indicators – 1993*

Appendix table 7–15.
Public attitudes toward scientists and scientific research: 1992

Sex, level of education, and attentiveness	A	B	C	N
	Percentage agreeing			
All adults	63	52	79	3,111
Sex				
Male	64	54	78	1,490
Female	62	51	80	1,621
Formal education				
9 years or less	44	68	80	346
10 or 11 years	68	56	80	338
High school degree	64	54	79	1,818
College degree	67	38	77	414
Graduate/professional degree	72	38	78	195
Science/math education				
Low	59	59	80	1,743
Middle	66	45	78	853
High	71	43	76	515
Attentiveness to science/technology policy				
Attentive public	69	54	79	247
Interested public	62	50	82	1,261
Residual	63	54	76	1,602

A *"The fact that scientists repeat and check each other's work effectively prevents fraud or cheating by scientists."*

B *"Many scientists make up or falsify research results to advance their careers or make money."*

C *"Most scientists want to work on things that will make life better for the average person."*

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–10. *Science & Engineering Indicators – 1993*

Appendix table 7–16.

Public assessment of the likelihood of certain results from science and technology: 1992

Sex, level of education, and attentiveness	A	B	C	D	E	F	N
	Percentage finding result very likely						
All adults	26	44	48	45	40	46	3,111
Sex							
Male	29	45	50	47	43	43	1,490
Female	22	44	46	43	38	49	1,621
Formal education							
9 years or less	37	35	47	35	35	39	346
10 or 11 years	28	41	40	42	42	47	338
High school degree	23	44	50	47	42	50	1,818
College degree	27	52	45	47	36	38	414
Graduate/professional degree	20	53	50	48	44	43	195
Science/math education							
Low	27	42	48	45	41	48	1,743
Middle	22	45	48	45	39	46	853
High	26	52	48	45	40	41	515
Attentiveness to science/technology policy							
Attentive public	28	54	43	50	49	38	247
Interested public	30	48	51	50	42	48	1,261
Residual	22	40	46	40	38	46	1,602

"Now let me ask you to think about the long-term future. I am going to read you a list of possible results and ask you how likely you think it is that each of these results will occur in the next 25 years or so."

A *"The accidental release of a dangerous manmade organism that could contaminate the environment."*
B *"The development of medical technologies that will extend the average age of Americans to approximately 90 years."*
C *"A major nuclear power plant accident."*
D *"A cure for the common forms of cancer."*
E *"A vaccine for the disease AIDS."*
F *"A significant deterioration in the quality of our environment."*

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–11.

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Appendix table 7–17.

Public assessment of the effect of science and technology on selected aspects of life: 1985 and 1992

Sex, level of education, and attentiveness to science/technology	Year	Standard of living		General working conditions		Public health		World peace		Individual enjoyment of life		N
		Positive effect	Negative effect	Positive effect	Negative effect	Positive effect	Negative effect	Positive effect	Negative effect	Positive effect	Negative effect	
		Percent										
All adults	1985	84	9	79	12	83	12	42	33	70	15	2,005
	1992	83	6	77	9	79	11	49	25	73	10	2,001
Male	1985	86	7	82	10	85	11	44	33	75	11	950
	1992	87	5	78	9	81	11	51	26	77	10	950
Female	1985	82	10	76	13	81	13	41	33	65	18	1,054
	1992	80	7	76	10	77	11	47	24	69	10	1,051
11 years or less formal education	1985	73	15	63	22	71	20	43	32	54	22	507
	1992	72	11	65	17	67	19	49	27	63	15	403
High school degree	1985	85	7	82	9	86	10	42	35	73	14	1,147
	1992	84	6	77	9	80	10	48	24	73	10	1,202
College degree	1985	93	3	89	6	89	7	42	29	80	8	229
	1992	93	2	87	4	88	7	48	26	80	7	235
Graduate/professional degree	1985	99	1	93	3	92	8	40	28	82	8	121
	1992	95	2	91	3	93	4	53	21	82	6	161
Public attentive to science/ technology policy	1985	90	5	83	12	82	14	46	33	81	11	235
	1992	87	4	79	12	84	10	48	32	74	13	199
Public interested in science/ technology policy	1985	86	8	80	12	84	11	43	33	73	13	871
	1992	84	7	80	9	78	12	52	23	76	9	802
Residual	1985	80	10	76	11	82	12	40	33	63	17	898
	1992	82	6	74	10	79	10	47	24	70	11	999

"Now, I want to read you a short list of areas and for each one, please tell me if you think that science and technology have had a positive effect, a negative effect, or neither kind of effect."

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–12.

Science & Engineering Indicators – 1993

Appendix table 7–18.
Public assessment of the benefits/harms of scientific research: 1979–92

Sex, level of education, and attentiveness	Year	Benefits strongly exceed harms	Benefits exceed harms	Benefits equal harms[1]	Harms exceed benefits	Harms strongly exceed benefits	N
		Percent					
All adults	1979	46	23	21	6	4	1,635
	1981	42	28	13	12	5	1,536
	1985	44	24	13	13	6	2,005
	1988	53	22	13	8	4	1,042
	1990	47	23	17	10	3	2,033
	1992	42	31	11	12	5	997
Male	1979	51	22	17	6	3	773
	1981	48	27	11	10	5	724
	1985	48	22	11	13	6	950
	1988	56	22	11	7	4	498
	1990	54	23	10	9	4	964
	1992	45	30	9	11	5	464
Female	1979	42	24	25	6	4	862
	1981	37	28	16	14	5	812
	1985	40	25	15	14	6	1,054
	1988	51	21	5	9	4	544
	1990	40	23	23	11	3	1,070
	1992	40	31	13	12	4	533
11 years or less formal education	1979	26	23	36	10	6	465
	1981	26	23	25	18	9	385
	1985	20	21	27	19	13	507
	1988	33	24	22	15	6	293
	1990	24	23	33	16	4	495
	1992	24	33	17	20	7	215
High school degree	1979	50	25	15	5	3	932
	1981	43	31	10	12	4	886
	1985	47	25	11	13	4	1,143
	1988	56	23	11	6	4	574
	1990	49	25	13	10	3	1,179
	1992	41	32	10	12	5	579
College degree	1979	69	17	9	2	3	238
	1981	64	22	7	4	2	264
	1985	67	22	3	6	2	349
	1988	79	14	4	2	1	175
	1990	70	18	8	3	1	359
	1992	66	22	8	3	2	203
Attentive public for new scientific discoveries	1988	60	26	4	5	3	81
	1990	61	19	12	5	3	168
	1992	48	27	12	9	4	94

"People have frequently noted that scientific research has produced both beneficial and harmful consequences. Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits?

"Would you say that the balance has been strongly in favor of beneficial results, or only slightly? Would you say that the balance has been strongly in favor of harmful results, or only slightly?"

NOTE: "Don't know" responses are not included.

[1] Offered as a response category for the first time in 1990; in prior years, volunteered by respondent.

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

Science & Engineering Indicators – 1993

See figure 7–13.

Appendix table 7–19.
Public preferences for spending in the United States: 1981–92

Problem area	Government is spending	1981	1983	1985	1988	1990	1992
		Percent					
Exploring space	Too little	18	17	9	17	9	12
	Too much	43	39	45	42	52	50
Reducing pollution	Too little	52	54	69	76	76	72
	Too much	14	11	6	4	5	7
Improving health care	Too little	61	NA	68	68	75	79
	Too much	6	NA	3	2	3	5
Scientific research	Too little	31	NA	29	34	30	34
	Too much	18	NA	18	15	16	19
Improving education	Too little	62	71	73	76	77	81
	Too much	6	5	3	4	4	4
Helping older people	Too little	73	NA	72	76	75	73
	Too much	3	NA	3	2	2	4
Improving national defense	Too little	33	19	11	11	15	15
	Too much	26	47	50	53	40	40
Helping low-income persons	Too little	45	NA	54	55	57	56
	Too much	24	NA	13	12	15	17
		N = 1,659	1,631	2,005	2,041	2,033	2,001

"We are faced with many problems in this country. I'm going to name some of these problems, and for each one, I'd like you to tell me if you think that the government is spending too little money on it, about the right amount, or too much."

NA = not asked

NOTE: The "Improving national defense" question was asked on a split ballot in 1988, therefore N = 1,013.

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–92, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–15. *Science & Engineering Indicators – 1993*

Appendix table 7–20.

Public preferences for spending in the United States: 1992

Sex, level of education, and attentiveness	Scientific research		Education		Elderly		Space exploration		Pollution		Health care		Defense		Low-income persons		
	Too little	Too much	Too little	Too much	Too little	Too much	Too little	Too much	Too little	Too much	Too little	Too much	Too little	Too much	Too little	Too much	N
	Percent																
All adults	34	19	81	4	73	4	12	50	72	7	79	5	15	40	56	17	2,001
Sex																	
Male	37	19	77	6	65	6	17	45	72	7	74	6	12	43	54	18	950
Female	31	19	86	2	80	2	9	56	71	6	84	3	18	37	57	16	1,051
Formal education																	
9 years or less	35	24	68	5	73	3	13	55	61	13	67	8	17	33	56	10	196
10 or 11 years	37	28	87	4	84	2	11	58	75	11	88	2	26	39	72	9	207
High school degree	30	20	83	3	77	3	12	53	73	5	82	4	15	39	56	18	1,202
College degree	40	9	82	4	55	6	12	38	71	4	74	6	9	48	42	21	235
Graduate/professional degree	46	10	75	7	53	8	17	35	69	7	69	7	8	45	49	19	161
Science/math education																	
Low	31	22	82	4	78	2	11	57	70	8	81	4	19	35	61	14	1,175
Middle	32	18	82	3	71	3	14	48	75	4	81	4	13	45	51	21	467
High	43	11	80	5	57	8	17	34	73	4	72	6	8	49	43	21	358
Attentiveness to science/technology policy																	
Attentive public	43	12	83	4	70	5	22	44	74	6	80	2	13	45	53	12	199
Interested public	39	16	82	3	75	3	15	46	75	5	81	3	15	41	58	16	802
Residual	28	23	81	5	72	4	8	55	68	8	77	6	16	39	54	18	999

"We are faced with many problems in this country. I'm going to name some of these problems, and for each one, I'd like you to tell me if you think that the government is spending too little money on it, about the right amount, or too much."

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–15.

Science & Engineering Indicators – 1993

Appendix table 7–21.
Public knowledge of science and technology: 1992

Sex, level of education, and level of attentiveness	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	N
	Percentage answering correctly																
All adults	81	73	86	65	37	46	35	38	79	45	94	45	67	75	71	46	2,001
Sex																	
Male	88	78	88	57	49	56	29	45	85	49	95	48	71	87	79	55	950
Female	75	68	83	72	26	38	41	31	74	41	93	42	62	63	64	37	1,051
Formal education																	
9 years or less	76	43	77	42	15	30	12	28	74	22	88	40	51	68	58	23	196
10 or 11 years	78	63	82	51	27	38	16	32	75	46	95	31	59	59	46	21	207
High school degree	81	74	87	68	35	44	34	35	77	43	94	43	66	74	72	46	1,202
College degree	86	87	90	75	56	62	56	47	86	59	95	63	77	86	84	66	235
Graduate/professional degree	89	94	87	76	67	72	64	59	94	68	98	60	82	89	91	71	161
Science/math education																	
Low	78	64	83	60	26	35	25	32	74	38	94	39	62	70	63	33	1,175
Middle	84	80	89	68	43	54	39	40	81	48	95	46	68	79	79	58	467
High	88	92	89	77	66	75	62	52	92	64	95	64	78	86	90	73	358
Attentiveness to science/technology policy																	
Attentive public	86	77	83	59	47	62	38	51	90	60	92	55	71	76	76	51	199
Interested public	82	73	89	63	39	47	36	43	80	48	95	45	69	77	73	45	802
Residual	79	72	84	68	33	43	33	31	76	39	94	43	64	73	69	45	999

A *"The center of the earth is very hot."* (True)
B *"All radioactivity is manmade."* (False)
C *"The oxygen we breathe comes from plants."* (True)
D *"It is the father's gene which decides whether the baby is a boy or a girl."* (True)
E *"Lasers work by focusing sound waves."* (False)
F *"Electrons are smaller than atoms."* (True)
G *"Antibiotics kill viruses as well as bacteria."* (False)
H *"The universe began with a huge explosion."* (True)
I *"The continents on which we live have been moving their location for millions of years and will continue to move in the future."* (True)
J *"Human beings, as we know them today, developed from earlier species of animals."* (True)
K *"Cigarette smoking causes lung cancer."* (True)
L *"The earliest humans lived at the same time as the dinosaurs."* (False)
M *"Radioactive milk can be made safe by boiling it."* (False)
N *"Which travels faster: light or sound?"* (Light)
O *"Does the earth go around the sun, or does the sun go around the earth?"* (Earth around the sun)
P *"How long does it take for the earth to go around sun: one day, one month, or one year?"* (One year)

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–16.

Science & Engineering Indicators – 1993

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Appendix table 7–22.

International comparisons of public knowledge of science and technology: 1992

Region/country	A	B	C	D	E	F	G	H	I	J	K	L	Mean percentage correct 12-item scale	Mean percentage correct 6-item scale	N
	Percent														
European Community	84	80	42	82	49	50	27	36	53	65	51	45	55.5	50.8	12,800
Belgium	90	72	44	82	44	44	19	34	52	70	51	41	53.6	50.2	1,000
Denmark	91	89	38	91	40	59	47	41	66	76	46	54	61.5	59.8	1,000
France	87	79	48	91	56	54	28	36	60	71	54	48	59.3	55.7	1,000
Germany	93	82	39	84	44	61	31	40	47	58	50	46	56.3	49.8	2,000
Greece	75	85	37	58	53	27	15	12	34	48	60	43	45.6	34.0	1,000
Ireland	82	68	33	66	58	37	28	28	50	67	41	30	49.0	45.3	1,000
Italy	82	82	48	80	51	37	13	31	58	63	59	28	52.7	48.8	1,000
Luxembourg	84	85	45	79	41	56	12	34	53	66	64	61	56.7	48.5	500
The Netherlands	87	84	39	86	42	56	38	47	62	49	42	65	58.1	53.5	1,000
Portugal	71	86	30	56	40	24	12	20	32	57	46	30	42.0	34.5	1,000
Spain	81	73	42	73	38	39	25	30	40	70	64	47	51.8	46.7	1,000
United Kingdom	88	81	37	87	56	57	39	45	65	75	48	54	61.0	58.0	1,300
Japan	NA	NA	29	59	NA	NA	13	21	53	73	NA	NA	—	41.3	1,457
United States	81	86	46	79	65	45	35	37	73	45	46	60	58.2	52.5	2,980

A *"The center of the earth is very hot."* (True)

B *"The oxygen we breathe comes from plants."* (True)

C *"Electrons are smaller than atoms."* (True)

D *"The continents on which we live have been moving for millions of years."* (True)

E *"It is the father's gene that determines the gender of a child."* (True)

F *"The earliest humans lived at the same time as the dinosaurs."* (False)

G *"Antibiotics kill viruses as well as bacteria."* (False)

H *"Lasers work by focusing sound waves."* (False)

I *"All radioactivity is manmade."* (False)

J *"Human beings, as we know them today, developed from earlier species of animals."* (True)

K *"Does the earth go around the sun, or does the sun go around the earth?"* (earth around the sun)

L *"Some numbers are especially lucky for some people."* (False)

— = not applicable; NA = not asked

NOTE: The six-item scale is comprised of questions C, D, G, H, I, and J.

SOURCES: Commission of the European Communities, *Europeans, Science and Technology – Public Understanding and Attitudes* [Eurobarometer 38.1] (Brussels: Commission of the European Communities, 1993). J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979-1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and National Institute of Science and Technology Policy (Japan), *Japan National Study, 1991* (Tokyo: NISTEP, 1992).

See figure 7–17.

Appendix table 7–23.
Public knowledge of biomedical topics: 1993

Sex, level of education, and attentiveness	A	B	C	D	E	F	G	H	I	J	N
	Percentage answering correctly										
All adults	59	42	77	46	82	56	41	73	78	64	3,111
Sex											
Male	62	39	77	44	84	53	47	73	78	68	1,490
Female	56	45	76	48	80	59	35	72	77	59	1,621
Formal education											
9 years or less	35	11	82	21	48	60	35	44	49	54	346
10 or 11 years	38	35	83	27	72	57	28	50	76	57	338
High school degree	62	45	76	48	86	52	39	78	81	63	1,818
College degree	75	54	72	62	93	65	52	87	83	71	414
Graduate/professional degree	82	62	70	74	98	76	65	83	85	84	195
Science/math education											
Low	48	34	80	38	74	51	34	64	73	59	1,743
Middle	68	49	74	51	89	58	46	81	83	66	853
High	82	59	71	68	96	70	55	87	85	76	515
Attentiveness to science/technology											
Attentive public	69	42	72	57	85	56	51	80	81	72	247
Interested public	62	42	78	44	82	59	41	69	77	67	1,261
Residual	55	43	77	46	81	54	39	74	77	60	1,602

A *"DNA regulates inherited characteristics for all plants and animals."* (True)

B *"Human beings can survive on almost any combination of foods, provided that the total diet includes enough calories."* (False)

C *"The body's immune system protects us from bacteria as well as viruses."* (True)

D *"Senility is inevitable as the brain ages and loses tissue."* (False)

E *"All bacteria are harmful to humans."* (False)

F *"In general, to be effective, a vaccine must be administered before an infection occurs."* (True)

G *"Human beings, as we know them today, developed from earlier species of animals."* (True)

H *"Intelligence in humans is related to the size of the brain."* (False)

I *"The human immune system has no defense against viruses."* (False)

J *"The process of evolution is continuing today."* (True)

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979-1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and National Institute of Science and unpublished tabulations.

See figure 7–18.

Science & Engineering Indicators – 1993

Appendix table 7–24.

Public understanding of the cause of acid rain: 1992

Sex, level of education, and attentiveness	Gave scientifically correct explanation of cause	Gave general description of cause	Linked cause to pollution	N
	Percent			
All adults	8	5	37	997
Sex				
Male	14	8	34	464
Female	2	2	40	533
Formal education				
9 years or less	5	2	19	102
10 or 11 years	0	5	30	113
High school degree	7	3	40	579
College degree	15	11	41	130
Graduate/professional degree	18	11	44	72
Science/math education				
Low	4	4	35	593
Middle	8	2	42	224
High	19	12	38	180
Attentiveness to science/technology				
Attentive public	13	8	38	94
Interested public	9	4	40	385
Residual	5	4	34	518

"When you read or hear the term 'acid rain,' do you have a clear understanding of what it means, a general sense of what it means, or little understanding of what it means?"

"What do you believe is the primary cause of acid rain?" [Asked if respondents said they had a clear or general understanding of acid rain.]

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–19.

Appendix table 7–25.

Public understanding of the ozone layer: 1992

Sex, level of education, and attentiveness	Understood thinning	Knew location	Knew harms	N
	Percent			
All adults	26	7	42	997
Sex				
Male	31	10	50	464
Female	21	4	35	533
Formal education				
9 years or less	10	2	27	102
10 or 11 years	26	2	30	113
High school degree	24	6	40	579
College degree	37	15	61	130
Graduate/professional degree	44	14	56	72
Science/math education				
Low	20	5	35	593
Middle	29	7	46	224
High	41	16	57	180
Attentiveness to science/technology policy				
Attentive public	51	14	60	94
Interested public	28	7	45	385
Residual	20	6	36	518

"Please tell me, in your own words, why there is a hole in the ozone layer?

"Do you know where the hole is located? Where is it located?

"So far as you know, are there any harms or dangers that might result from a hole in the ozone layer?"

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992, Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–19.

Appendix table 7–26.
Public knowledge of selected environmental concepts: 1992

Sex, level of education, and attentiveness	Hole in ozone layer can cause skin cancer	Greenhouse effect can raise sea level	Acid rain causes damage to forests	Car emissions are not related to acid rain	N
	Percentage agreeing				
All adults	73	45	89	16	1,004
Sex					
Male	72	54	91	16	486
Female	75	37	87	16	518
Formal education					
9 years or less	62	43	82	20	94
10 or 11 years	68	40	82	17	94
High school degree	76	42	90	16	623
College degree	69	55	92	13	104
Graduate/professional degree	75	60	95	13	89
Science/math education					
Low	71	41	86	17	582
Middle	77	43	92	15	244
High	77	60	95	12	178
Attentiveness to science/technology policy					
Attentive public	68	61	84	17	105
Interested public	71	45	91	18	417
Residual	76	41	88	14	481

"Could you please tell me if you think the following statements are true or false?" (All statements are true.)

SOURCES: J.D. Miller and L.K. Pifer, *Public Attitudes Toward Science and Technology, 1979–1992. Integrated Codebook* (Chicago: International Center for the Advancement of Scientific Literacy, Chicago Academy of Sciences, 1993), and unpublished tabulations.

See figure 7–19.

Appendix table 7–27.

Understanding of selected scientific concepts by high school seniors: 1990 and 1993

Concept	Response	Seniors 1990	Seniors 1993
		Percent	
Human beings, as we know them today, developed from earlier species of animals.	Agree	39	33
	Disagree	24	24
	Undecided	37	43
Smoking causes serious health problems.	Agree	80	75
	Disagree	4	3
	Undecided	16	23
In the entire universe, it is likely that there are thousands of planets like our own on which life could have developed.	Agree	47	44
	Disagree	9	8
	Undecided	44	48
The continents on which we live have been moving their location for millions of years and will continue to move in the future.	Agree	63	57
	Disagree	5	4
	Undecided	32	39
Some numbers are especially lucky for me.	Agree	22	26
	Disagree	44	37
	Undecided	34	37
A scientific theory is a scientist's best understanding of how something works.	Agree	64	61
	Disagree	7	7
	Undecided	29	32
All scientific theories change from time to time as scientists improve their understanding of nature.	Agree	70	64
	Disagree	4	4
	Undecided	26	32
	N =	1,751	1,650

SOURCE: J.D. Miller and L.K. Pifer, *Longitudinal Study of American Youth* (DeKalb, IL: Social Science Research Institute, Northern Illinois University, 1993), special tabulations.

See figure 7–20.

Appendix table 7–28.
Attitudes toward science and technology among high school seniors: 1990 and 1993

Statement	Response	Seniors	
		1990	1993
		Percent	
Scientific invention is largely responsible for our standard of living in the United States.	Agree	68	62
	Disagree	3	3
	Undecided	29	35
Overall, science and technology have caused more good than harm.	Agree	47	44
	Disagree	19	19
	Undecided	34	37
On balance, computers and factory automation will create more jobs than they will eliminate.	Agree	33	26
	Disagree	18	22
	Undecided	49	52
One trouble with science is that it makes our way of life change too fast.	Agree	26	24
	Disagree	33	31
	Undecided	41	45
New inventions will always be found to counteract any harmful consequences of technological development.	Agree	32	25
	Disagree	20	20
	Undecided	48	55
In this complicated world of ours, the only way we can know what is going on is to rely on leaders and experts who can be trusted.	Agree	33	28
	Disagree	29	28
	Undecided	38	44
Scientific researchers are dedicated people who work for the good of humanity.	Agree	52	43
	Disagree	7	9
	Undecided	41	48
Because of their knowledge, scientific researchers have a power that makes them dangerous.	Agree	27	26
	Disagree	32	30
	Undecided	41	44
	N =	1,751	1,650

SOURCE: J.D. Miller and L.K. Pifer, *Longitudinal Study of American Youth* (DeKalb, IL: Social Science Research Institute, Northern Illinois University, 1993), special tabulations.

See figure 7–21.

Appendix B
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Appendix C
Abbreviations

AMS	American Mathematical Society
APL	Applied Physics Laboratory
ARPA	Advanced Research Projects Agency
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
BRDPI	biomedical research and development price index
CAD/CAM	computer-aided design and computer-aided manufacturing
CCSSO	Council of Chief State School Officers
CFC	chlorofluorocarbon
CRADA	cooperative research and development agreement
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
EAE	emerging Asian economy
EC	European Community
EPA	Environmental Protection Agency
EPO	European Patent Office
FCCSET	Federal Coordinating Council for Science, Engineering, and Technology
FFRDC	federally funded research and development center
FTE	full-time equivalent
FTTA	Federal Technology Transfer Act
FY	fiscal year
GDP	gross domestic product
GPA	grade point average
GSP	gross state product
GSS	General Social Survey
GUF	general university funds
HHS	Department of Health and Human Services
IAEP	International Assessment of Educational Progress
IR&D	independent research and development
ISIC	International Standard Industrial Classification
JRV	joint research and development venture
LSAY	Longitudinal Study of American Youth
MER	market exchange rate
NAEP	National Assessment of Educational Progress
NASA	National Aeronautics and Space Administration
NCRA	National Cooperative Research Act of 1984
NCTM	National Council of Teachers of Mathematics
NCTTA	National Competitiveness Technology Transfer Act
NELS:88	National Education Longitudinal Study of 1988
NIE	newly industrialized economy
NIH	National Institutes of Health
NIST	National Institute for Standards and Technology
NS&E	natural science and engineering
NSF	National Science Foundation
NSTC	National Science and Technology Council
OECD	Organisation for Economic Co-operation and Development
OES	Occupational Employment Statistics
PC	personal computer
PCAST	President's Committee of Advisors on Science and Technology
PECC	Pacific Economic Cooperation Council
P.L.	public law
PPP	purchasing power parity
R&D	research and development
R&E	research and experimentation
RA	research assistantship
RDNA	recombinant DNA
RDT&E	research, development, test, and evaluation
S&E	science and engineering
S&T	science and technology
SAT	Scholastic Aptitude Test
SBA	Small Business Administration
SBIR	Small Business Innovation Research
SDR	Survey of Doctorate Recipients
SIMS	Second International Mathematics Study
SIR	statutory invention registration
SISS	Second International Science Study
SME	science, mathematics, and engineering
TA	teaching assistantship
TRP	Technology Reinvestment Program
UIRC	university-industry research center
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USDA	Department of Agriculture
WPIL	World Patent Index Latest

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Appendix D
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